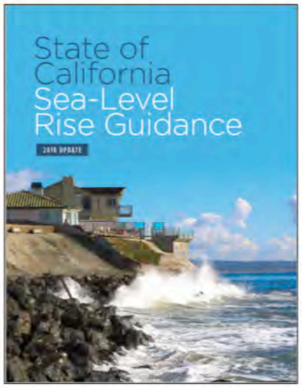
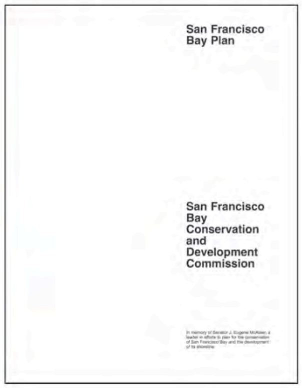
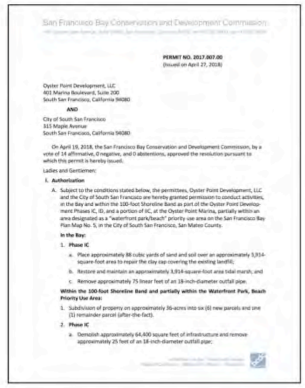
Policies to Permits:
Applying State SLR Guidance







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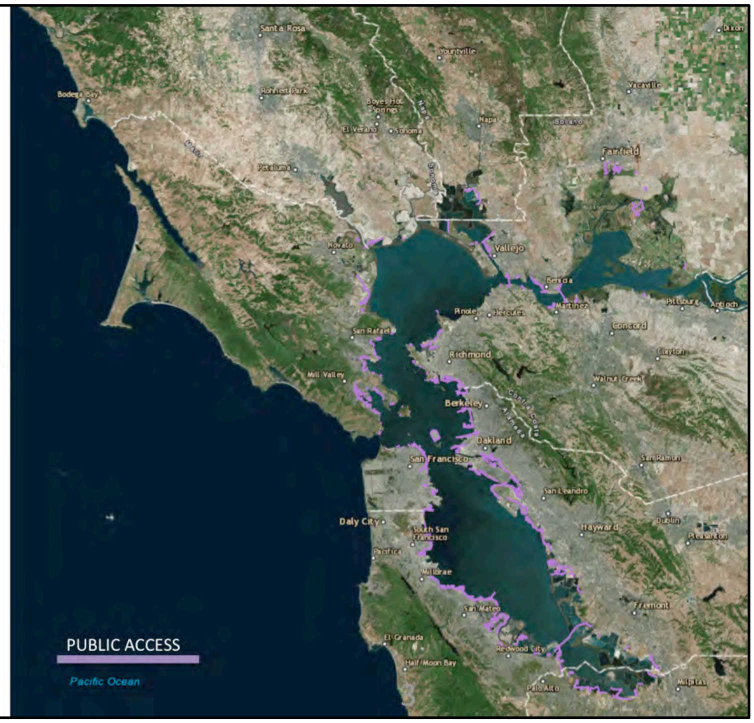
From Policies to Permits:
Applying the State Sea Level Rise Guidance to BCDC's Policies, Regulations, and Permits.

1. Quick Update on Jurisdiction
2. Climate Change Policy Review
3. Permit Condition Examples
4. Applying the 2018 Guidance
5. Discussion & Questions

Here's an Overview of our presentation.
Erik will run through the first three sections then Andrea will walk through several projects and additional discussion.

Jurisdiction

- Bay
- Certain Waterways
- 100-foot Shoreline Band
- Salt Ponds
- Suisun Marsh



BCDC has a lot of different types of jurisdiction, and where the project is in relationship to our jurisdiction will affect the way we analyze the effect of sea level rise and flooding on a project because the Commission's authority is different for the different jurisdictions.

In the Bay, BCDC has broad requirements that must be met to approve fill projects.

- Public benefits from fill clearly exceed public detriment
- Fill must be for water-oriented uses* (e.g., ports, airports, bridges, wildlife refuges, and recreation)
- No alternative upland location exists for the fill
- Fill is the minimum amount necessary to achieve the project purpose
- Fill minimizes harmful effects to the Bay
- Fill is constructed with sound safety standards (e.g., seismic, flooding hazards) – In order to meet sound safety standards, for example, the project must be consistent with the Bay Plan policies related to climate change.

*Water-oriented unless minor fill for improving shoreline appearance or public access

BCDC’s authority is much more limited in the 100-foot shoreline band. The only reason BCDC can deny a project in the 100-foot shoreline band is if the development fails to provide Maximum Feasible Public Access consistent with the project.

EXTRA NOTES

Priority Use Areas are areas set aside by the San Francisco Bay Plan for certain water-oriented uses, such as a public park near Crissy Field and the Presidio, or for a port uses, such as the dry-dock at Pier 70.

No general land-use authority – except in a Priority Use Area.

Bay Plan – Climate Change Policies

- Larger Shoreline Projects need a Risk Assessment
- Risk Assessments should:
    - Use current 100-year base flood elevation + **"best estimate of future sea level rise."**
    - Use **"best scientific data"** for mid-century and end of century sea level rise projections
    - Include current and planned flood protection
    - Depict all types of flooding, **degrees of uncertainty**, consequences of defense failure, and risks to habitat from proposed flood protection devices

The climate change policies were adopted to the Bay Plan in 2011. We'll take a couple minutes to elaborate on a few of these policies.

POLICY 2:

Larger Shoreline Projects need a risk assessment conducted by a qualified engineer

Larger shoreline project not defined, BCDC makes an assessment on a case-by-case basis.

Risk Assessments should:

- Use current 100-year base flood elevation that includes a "best estimate of future sea level rise"
- Use "best scientific data" for mid-century and end of century sea level rise projections. (We consider the best scientific data to be the State Guidance)**.**
- Include current and planned flood protection
- Depict all types of flooding, degrees of uncertainty, consequences of defense failure, and risks to habitat from proposed flood protection devices

Bay Plan - Climate Change Policies

- If a risk assessment determines an area is vulnerable to flooding that threatens public safety all projects should be designed to be:
  - "Resilient" to mid-century
    - **Resilient:** System is built to "absorb and rebound from the impacts of weather extremes or climate change and continue functioning without substantial outside assistance"
  - "Adaptive Management Plan" to end-of-century
    - **Adaptation:** "Project can adjust to climate change impacts by taking actions to reduce the potential damages, taking advantage of new opportunities arising from climate change, and accommodating the impacts"

POLICY 3
If a risk assessment determines an area is vulnerable to flooding that threatens public safety, projects should be designed to be:

o"Resilient" to mid-century

o**Resilient –** Defined in the findings of the Bay Plan policies: System is built to "absorb and rebound from the impacts of weather extremes or climate change and continue functioning without substantial outside assistance"

o"Adaptive Management Plan" to end-of-century

o**Adaptation --** Also defined in the findings of the Bay Plan policies. "Project can adjust to climate change impacts by taking actions to reduce the potential damages, taking advantage of new opportunities arising from climate change, and accommodating the impacts"

As part of the 2011 climate change update, BCDC adopted Public Access policies related to sea level rise and flooding from storms.

Public Access Policies

Also worth noting is that "whenever public access is provided as a condition of development, the access should be permanently guaranteed.

Public access must be located, designed and managed to avoid flood impacts

Any public access provided as a condition of development within the shoreline band should:

- Either remain <u>viable</u> in the event of future sea level rise or flooding
- Or equivalent access consistent with the project should be provided nearby

- How we apply these policies will depend on the Commission's underlying authority. For a larger Bay fill project, all of these policies could apply and BCDC could ensure the resiliency of the entire project in the Bay. For a project in the shoreline band, however, BCDC is limited to ensuring that the public access is viable in the event of future sea level rise and storms. For example, if you had a residential development project in the Shoreline band, you could not deny a project on the basis that the development buildings would flood. Rather, BCDC would look to the public access and evaluate whether the project failed to achieve maximum feasible public access because the public access was not viable to flood risks or was not safe because of the risks of flooding as defined in the policies here.

- To determine if the public access is "Viable" we look to Climate Change policy 3. Viable means the project is resilient to mid-century and adaptable if the underlying

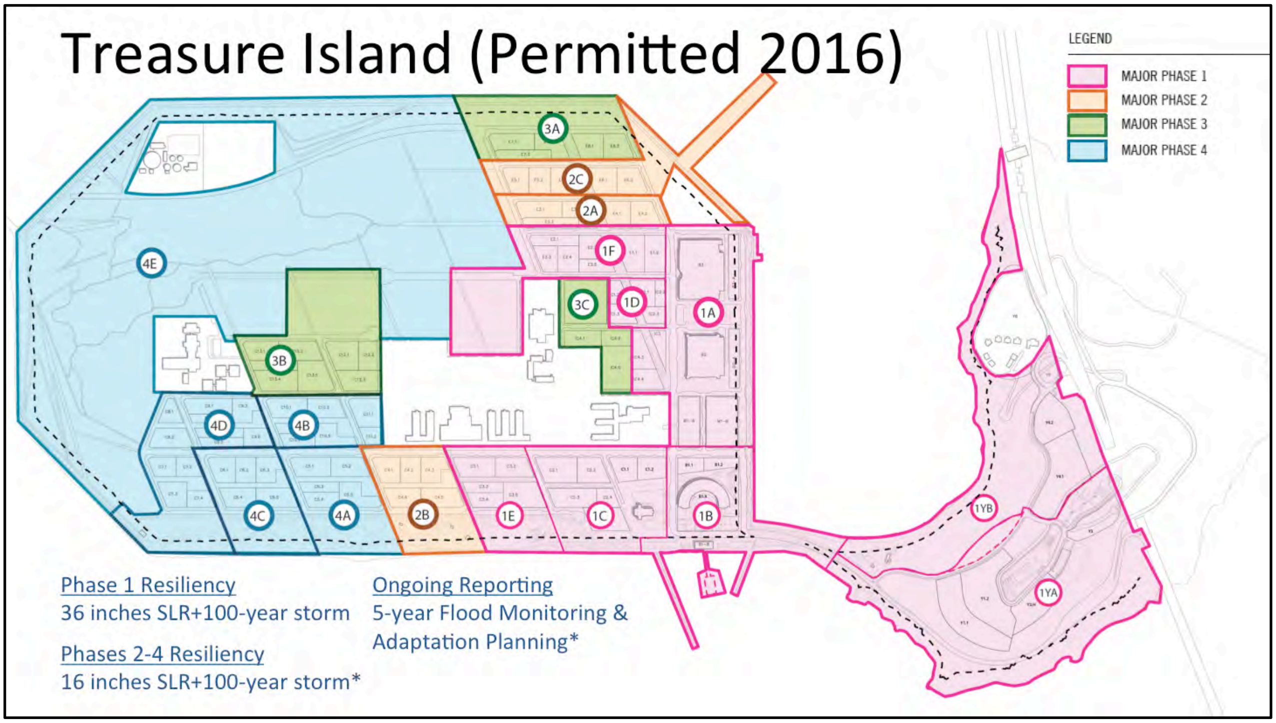
Tidal Marsh Policy 6
Tidal marsh restorations should be *resilient* and *adaptable* to sea level rise and incorporate a buffer that will allow for marsh migration

Consistent with Climate Change policy 4.

Shoreline Protection Policy 1
Shoreline protection should be integrated with current or planned adjacent shoreline protection

Safety of Fills Policy 4
New projects on fill or near the shoreline should be set back or built so the bottom floor is above the 100-year flood elevation that takes future sea level rise into account

Obviously, this photograph isn't showing those things.



Treasure Island is a multi-phase masterplan for the redevelopment of Treasure Island and Yerba Buena Island into a new mixed use community. The majority of the project, except for some outfalls and a ferry terminal, took place either in the 100-foot shoreline band or out of the Commission's jurisdiction.

The applicant conducted a thorough risk assessment of the public access around the entire perimeter of the island. Based on the risk assessment, the BCDC permit required that

Phase 1: Built to 36 inches above today's 100-year storm. 36-inches was the end of century projection under the older guidance. The permit included a threshold for adaptation.

> When the mean sea level in the Bay has risen 30 inches above year 2000 levels an adaptation planning process will be initiated to adapt the Phase 1 public access.
>
> This should provide approximately 8 years to plan and construct the improvements

Phases 2-4: Built to 16 inches above today's 100-year storm, therefore at risk earlier than Phase 1. 16-inches was the mean projection for mid-century under the previous guidance, so this was consistent with the policy to make the public access resilient to mid-century.

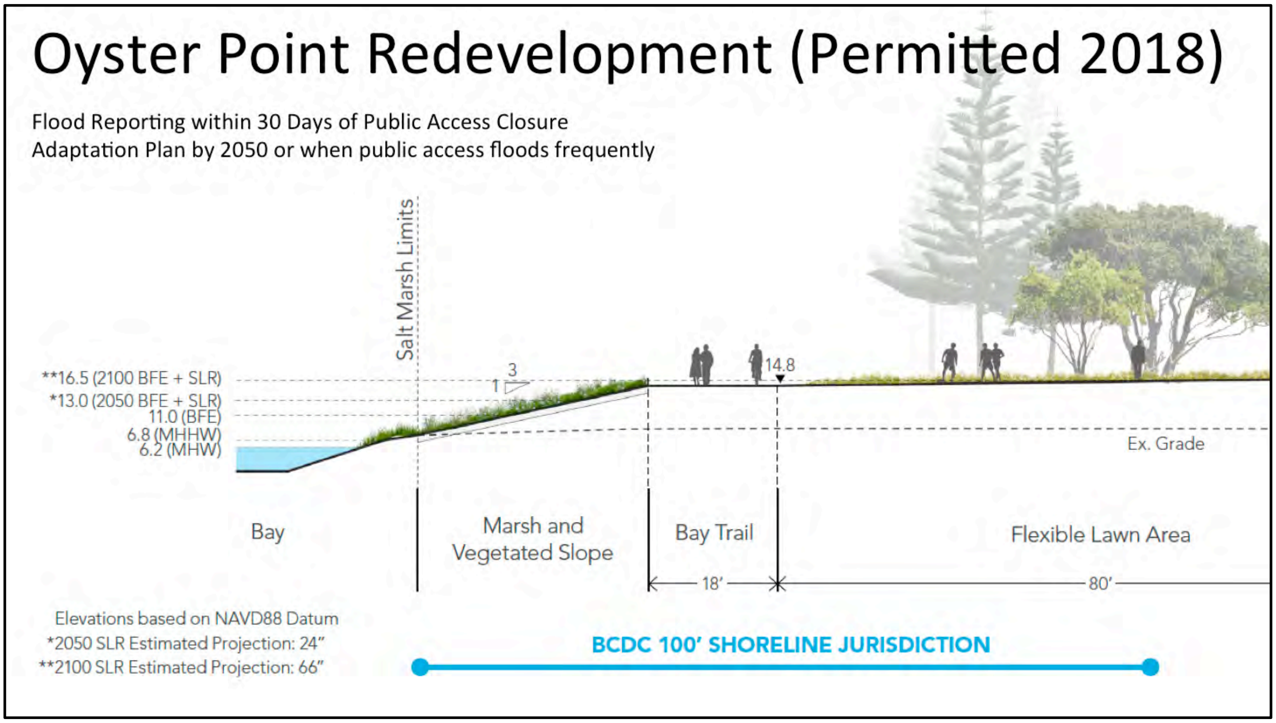
> When the mean sea level in the Bay has risen 12 inches above year 2000 levels a planning process will be initiated to adapt the Phase 2-4 public access.

BCDC staff wanted to provide flexibile adaptation pathway approach – we are not dictating a particular adaptation approach by, for example, require the construction of walls of a particular height. We are also providing for the possibility of updated better information in the future and incorporating that into the planning process. So even though the TI permit has strict thresholds, it can be modified in the future.

Monitoring Report every 5 years

> Review of best available science and update as needed of future sea level projections
>
> Changes in average tide levels in the Bay
>
> Report on any flooding that has occurred on site

Commission will review and approve.



Treasure Island is an island, so its in a unique circumstance in that it doesn't have to worry about linking up adaptation approaches to neighbors. It also has a tax base that can fund ongoing monitoring. The issue with creating a specific threshold for adaptation – 16-inches above 2000 mean sea level and you start planning as in the TI example – is that you can't just go out to a site on a given day and say, " today is the day that sea levels have reached the threshold" this is because water levels are measured on an epoch – over 20 years, or else do sophisticated modelling. You need to be routinely incorporating new data into your process. Not every community has the resources or the ability to do this.

OYSTER POINT which is a office and R&D development in South San Francisco was approved by the Commission in 2018, BCDC staff reviewed the project under the old guidance, but the new guidance was adopted just as the project was coming to the Commission so we did an analysis under the new guidance as well. The public access associated with the project was resilient to mid-century under all scenarios.

For Oyster Point Redevelopment project, BCDC wanted to provide the same flexible adaptation pathway approach. You don't want to dictate a particular solution, because you want to accommodate City or Regional efforts in the future. You want to leave open new innovative solutions for end-of-century that maybe we haven't thought of yet. You also want to incorporate new guidance and science. But we also wanted to craft conditions that were reasonable, enforceable, and achieveable for the City and the developer. To condition the project, we used a "TI Light"

Flood Reporting: Report any closure due to flooding within 30 days.
Adaptation Plan: By December 31, 2050, or when flooding of the public access due to sea level rise and associated storm events:

- Prepare new risk assessment for public access.
  - Incorporate new guidance, analysis of water levels, subsidence, flooding, etc.
  - Review and approval, implement with BCDC approval (permit amendments, plan review,

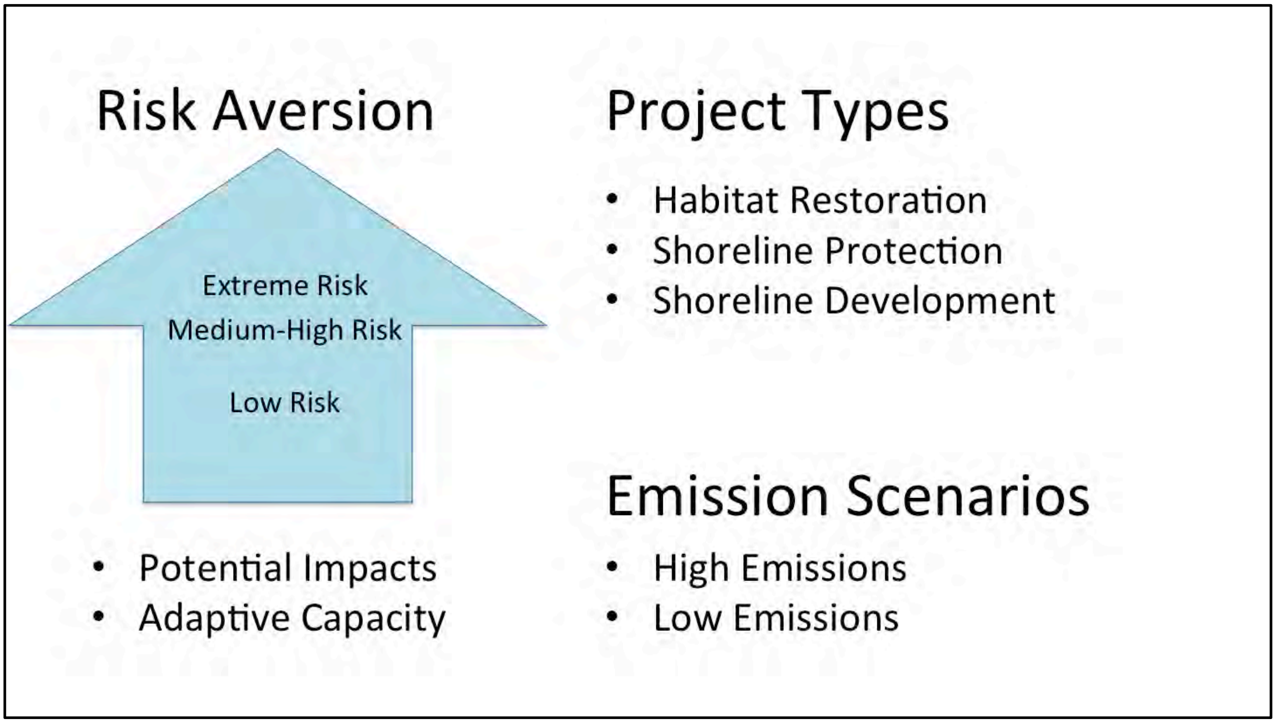
BCDC Staff Approach to Analysis

One Map, Many Futures – Provide a variety of scenarios for flooding from sea level rise and storms to show risk in an uncertain future.

Adaptation Pathways – Condition projects to provide flexibility in the future.

We face an uncertain future – so we want to provide you with broad suite of risk assessments – different scenarios showing different types of water levels, different storm events. When she walks through the projects with you, Andrea will show you one way we do this applying the new guidance.

We also want to condition projects to provide flexibility in the future.



Next we will walk through four examples that represent a significant amount of the projects we permit (outside of dredging!)
Tidal Habitat Restoration, Shoreline Protection, and Shoreline Development
The updated guidance provides categories for risk aversion and guidance on how to evaluate the risk taking into consideration potential impacts and adaptive capacity.
The updated guidance also provides a high and low emissions scenario for projected water levels.

Applying the Guidance

Permitted 2017

Hill Slough: Habitat Restoration & Roadway Improvement

Permitted 2018

Cesar Chavez Park: Shoreline Protection

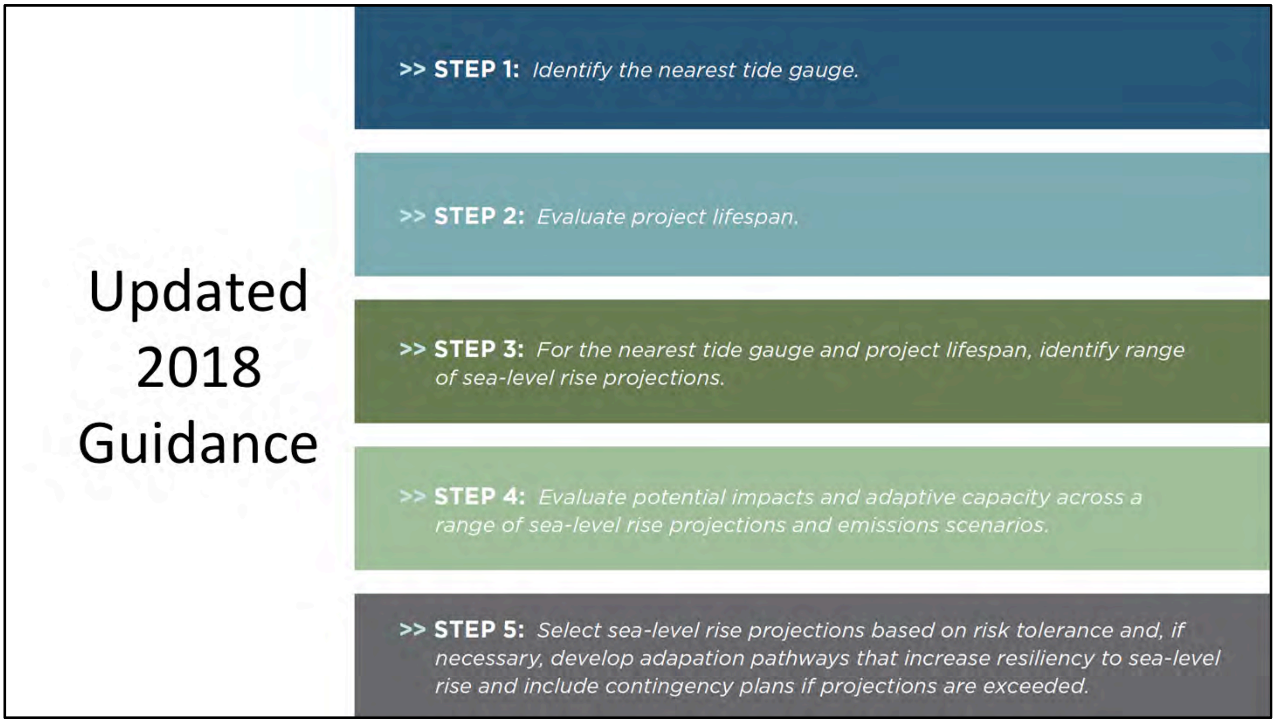
Upcoming Project Presentation Format

Shoreline Development

Existing Permit Issued Prior to Climate Change Policies

Jack London Square: Shoreline Development

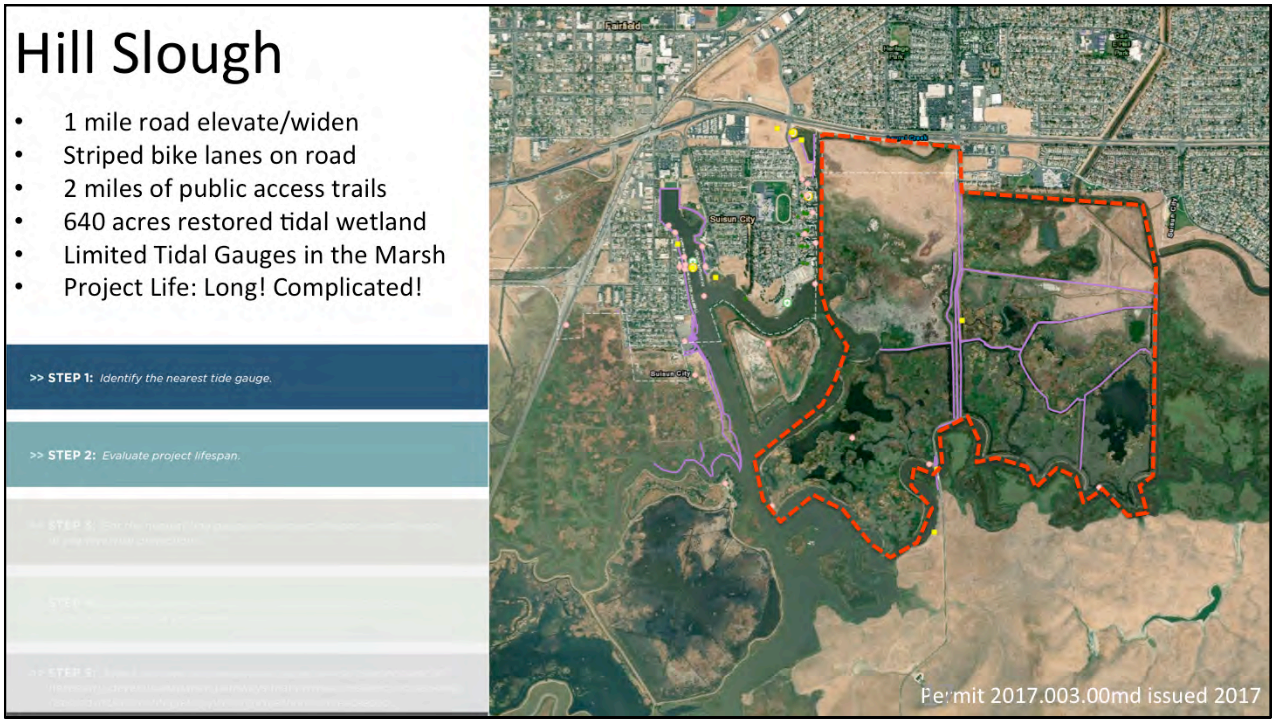
4 examples that represent a significant amount of the projects we permit (outside of dredging!)
Tidal Habitat Restoration, Shoreline Protection, Shoreline Development



We will use the following assessment steps to walk you through four example projects. As a reminder, these projects need to meet the criteria of Climate Change Policies that require a risk assessment for larger shoreline projects that must be resilient to mid-century and adaptable to end of century if the project life extends beyond mid-century.

Jenn showed already presented these steps so I'll just reference them here and then show you how we've applied them through the examples. Text below provides a brief summary of OPC Guidance, similar to what Jenn presented.

STEP ONE: identify the nearest tide gauge
The OPC guidance has one tide gauge for the SF Bay Area, but we are fortunate to have a 900 point tidal datum study conducted by AECOM in 2016 as part of the ART Bay Area program which provides a much more specific understanding of the tides in the region. So We use these tidal datum points to identify the closest gauge.
STEP TWO: evaluate project lifespan
For project lifespan definition, we often rely on the project proponents to provide this information, but a good definition of project lifespan is often longer than the life of a structure or a portion of a project. We want to know if the project is going to be in place at mid-century and end of century. If not expected to last through the end of century then we analyze to the end of the project life beyond mid-century.
STEP THREE:
Once we know tide gauge location and life span, we us the OPC sea level rise table to identify a range of SLR projections.
STEP FOUR:
We evaluate the potential impacts and adaptive capacity across a range of sea level rise projections and emissions scenarios.
And in **STEP FIVE:**
We select a sea level rise projection based on risk tolerance that is consistent with our laws and policies on

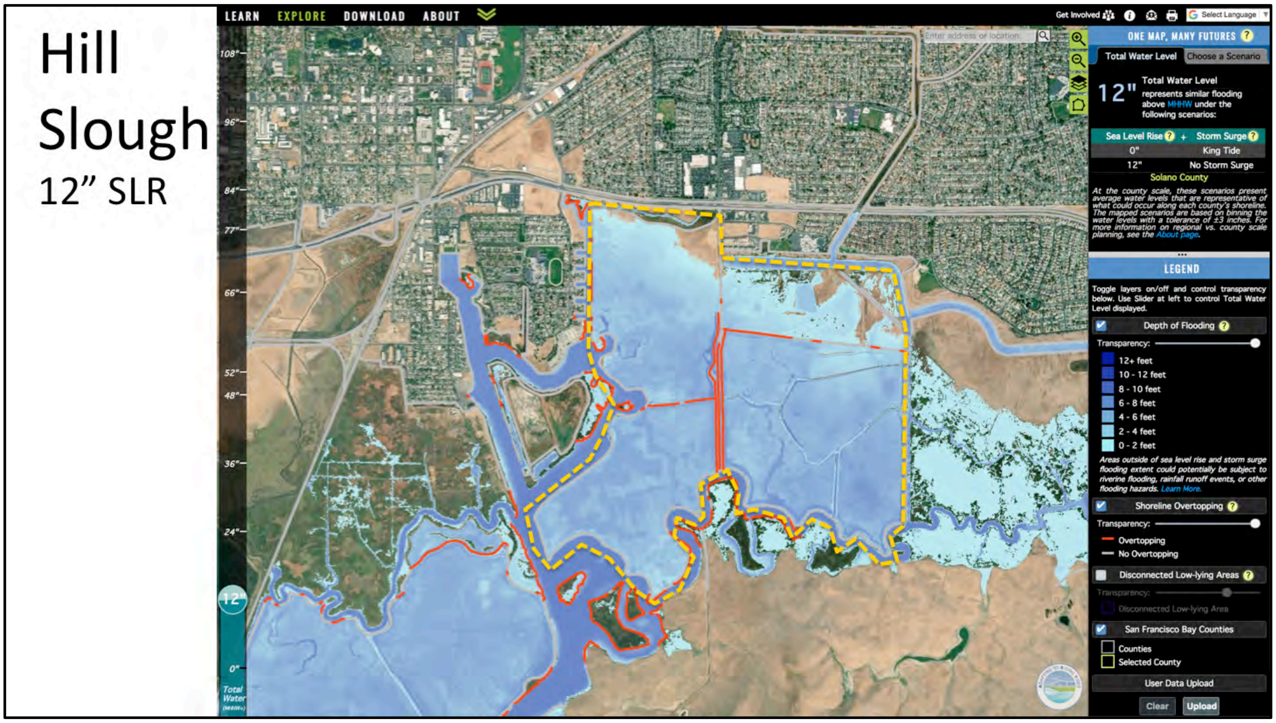


The first example is a tidal restoration project permitted in 2017.
Hill Slough is located in the Suisun Marsh. As part of the restoration project 640 acres of marsh will be restored to tidal wetland (area outlined by red dashed line.) In additional to the restoration, a regional road will be widened and elevated adding bike lanes and creating public access trails on top of the levees next to the wetlands.
Even though this project was permitted before the guidance was issued, we essentially followed the same steps outlined in the updated guidance.

So let's walk through the steps.

STEP ONE: Identify the nearest tide gauge
To understand the SLR implications, we looked for the closest tidal gauge to understand water levels relative to the proposed project.
The Nearest tidal gauge was 6 miles away and did not provide extreme tide flood elevations so we had consultants research best available data and provide us with this data.

STEP TWO Evaluate Project Lifespan:
Project lifespan for restoration projects is a sticky issue. After establishment, they should become restored landscapes that operate in perpetuity with little to no maintenance.
Restoration has monitoring for the first 5 -10 years but then is expected to be a fully functioning tidal wetland.
The Project lifespan of the Road and public access trails is more dependent on maintenance, but are expected to be there through the end of century unless they become permanently inundated, which is



In STEP THREE: Identify a range of sea level rise scenarios.
We used an early version of the flood explorer to look at different flood scenarios for the area. The project is outlined in the yellow dashed line.
The project area is low lying marsh and floods annually with king tides as shown here and will continue to flood as waters rise. The red lines show where the levees are overtopped, which also means Grizzly Island Road floods.

For this project, we were concerned with the climate change policies in relation to the required public access and the tidal restoration.

Hill Slough

Hill Slough Restoration Sea Level Projected Impacts

Road Elevation	10								
Trail Elevation	9.3								
	Curent Elevation in feet NAVD88			Elevation Project at 2050 (+1.33 feet)			Elevation Projected at 2100 (+4.58 feet)		
Blue means infrastructure is flooded	--			1.33			4.58		
Seasonal Water Level									
Mean lower low water (MLLW)	0.95	road	trail	2.28	road	trail	5.53	road	trail
Mean low water (MLW)	1.69	road	trail	3.02	road	trail	6.27	road	trail
Mean tide level (MTL)	3.78	road	trail	5.11	road	trail	8.36	road	trail
Mean high water (MHW)	5.86	road	trail	7.19	road	trail	10.44	road	trail
Mean higher high water (MHHW)	6.35	road	trail	7.68	road	trail	10.93	road	trail
Spring high tide level (12/14/2008)	7	road	trail	8.33	road	trail	11.58	road	trail
Flood Event									
FEMA 10 year non-coastal stillwater elevations (10%)	8.3	road	trail	9.63	road	trail	12.88	road	trail
FEMA 25 year coastal flood (4%)*	8.6	road	trail	9.93	road	trail	13.18	road	trail
FEMA 50 year non-coastal stillwater elevations (2%)	8.9	road	trail	10.23	road	trail	13.48	road	trail
100 year high tide (1% non-coastal stillwater elevation)	9.1	road	trail	10.43	road	trail	13.68	road	trail
FEMA 100 year coastal flood (1%)	10	road	trail	11.33	road	trail	14.58	road	trail

*estimate based on Stillwater elevations at Carquinez Strait

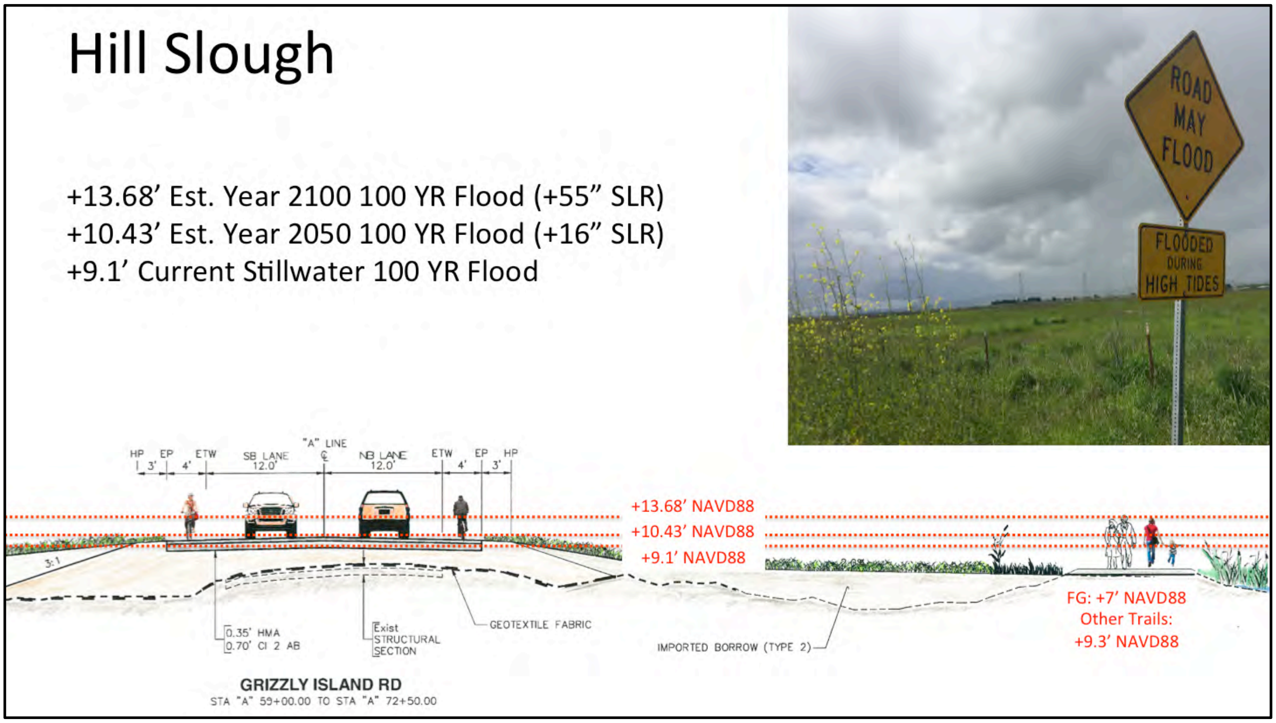
July 17, 2017

STEP FOUR:
We evaluated the potential impacts and adaptive capacity across a range of sea level rise projections. The project proponents provided a risk assessment with recommended mid-century and end of century sea level rise elevations using the best available science at the time.

And since we knew that the area already floods, we wanted to understand what was the resiliency of the proposed improvements with the higher elevations for the road and trails.
To do this analysis, we created a spreadsheet to see how proposed elevations would function with these projected sea level rise elevations.
At mid-century, we knew the road would not flood at mean higher high water, but would flood with a 100-year flood, but what about king tides, or other more frequent flood events?
we built this spreadsheet to understand the nuanced implications of sea level rise to provide us with additional information about the frequency of flooding and at what water elevations we would want to require adaptive management planning

Here's what we built into the spreadsheet.

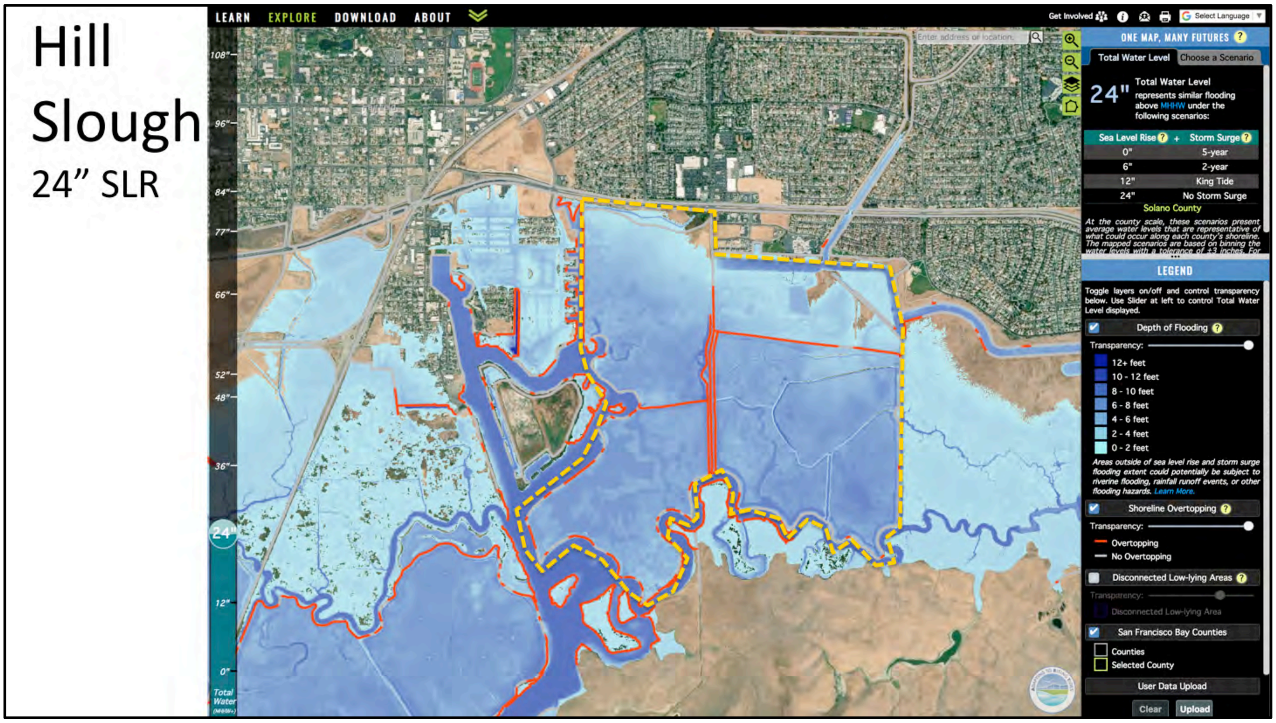
- Proposed Improvements and Proposed Elevation
- Current, Mid-century and End of Century water elevations for daily tides and extreme tide flood events.
- Blue means the proposed improvement will flood at that water level.
- As you notice, there's a big difference in water levels between Mean Higher High Water and the 100 year flood elevation.



And in STEP FIVE:
We select a sea level rise projection based on risk tolerance that is consistent with our laws and policies on resilience and adaptation criteria.

For this project because it's in the marsh, we know that the trails and roads with required public access will eventually flood. The required public access will likely need to be relocated, but there is room to adapt in this landscape.
As a result, we wrote the permit conditions to consider a lower risk tolerance knowing that future regional adaptation would be required to address the marsh and the required public access in the marsh.
Some details about the resiliency and adaptive capacity of the project:

- The road was designed so that it can be further elevated at a later date.
- The public access trails are designed to be functional after flood waters recede.
- The tidal restoration has been designed with shallow slopes so the habitat can migrate upland.
- There is a flood reporting requirement for closures of the road and trails greater than two weeks.
- Adaptation measures for the road and trails must begin with mean high water reaches 30 inches above current level.



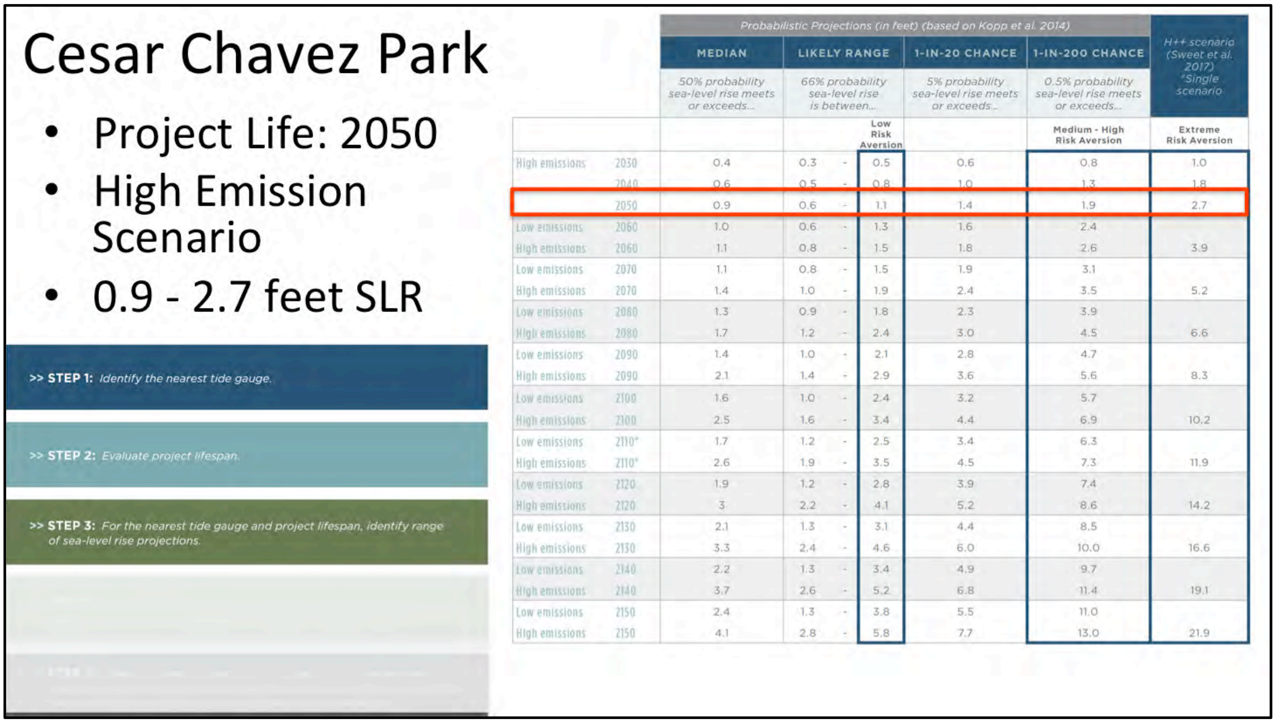
Finally, We also recognize that the flooding that may result when water levels exceed 16 inches above current levels in this area of Suisun Marsh and Suisun City cannot be addressed on a project-by-project basis, but will require an area-wide adaptation plan.

For the next project, we have a shoreline repair project that was an Administratively issued non-material amendment to an existing permit for Cesar Chavez park in Berkeley.
This project was evaluated with the OPC guidance.
So for the first steps, we located the nearest tidal datum to the project and evaluated the project lifespan.
As you can see, this datum is right next to the project site.

For the project lifespan we considered two factors:

- The park is a capped solid waste landfill that is susceptible to erosion from shoreline flooding.
- The City is conducting a long range planning effort for the park which will address sea level rise and flooding holistically.

For these reasons, the permittee agreed to a project lifespan for the shoreline protection until 2050.



		Probabilistic Projections (in feet) (based on Kopp et al. 2014)					H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE		1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds...	66% probability sea-level rise is between...		5% probability sea-level rise meets or exceeds...	0.5% probability sea-level rise meets or exceeds...	
				Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.4	0.3	0.5	0.6	0.8	1.0
	2040	0.6	0.5	0.8	1.0	1.3	1.8
	2050	0.9	0.6	1.1	1.4	1.9	2.7
Low emissions	2060	1.0	0.6	1.3	1.6	2.4	
High emissions	2060	1.1	0.8	1.5	1.8	2.6	3.9
Low emissions	2070	1.1	0.8	1.5	1.9	3.1	
High emissions	2070	1.4	1.0	1.9	2.4	3.5	5.2
Low emissions	2080	1.3	0.9	1.8	2.3	3.9	
High emissions	2080	1.7	1.2	2.4	3.0	4.5	6.6
Low emissions	2090	1.4	1.0	2.1	2.8	4.7	
High emissions	2090	2.1	1.4	2.9	3.6	5.6	8.3
Low emissions	2100	1.6	1.0	2.4	3.2	5.7	
High emissions	2100	2.5	1.6	3.4	4.4	6.9	10.2
Low emissions	2110*	1.7	1.2	2.5	3.4	6.3	
High emissions	2110*	2.6	1.9	3.5	4.5	7.3	11.9
Low emissions	2120	1.9	1.2	2.8	3.9	7.4	
High emissions	2120	3	2.2	4.1	5.2	8.6	14.2
Low emissions	2130	2.1	1.3	3.1	4.4	8.5	
High emissions	2130	3.3	2.4	4.6	6.0	10.0	16.6
Low emissions	2140	2.2	1.3	3.4	4.9	9.7	
High emissions	2140	3.7	2.6	5.2	6.8	11.4	19.1
Low emissions	2150	2.4	1.3	3.8	5.5	11.0	
High emissions	2150	4.1	2.8	5.8	7.7	13.0	21.9

For the next step, we used the San Francisco Bay Area table from the OPC guidance to identify a range of sea level rise scenarios which ranged from 11 to 32 inches for 2050. You'll notice that there are only high emissions scenarios through 2050.

The next step is to evaluate potential impacts and adaptive capacity across a range of sea level rise projections.

The OPC guidance recommends considering a variety of social, environmental and economic factors.

Consequence of Potential Impacts

- Capped Solid Waste Landfill vulnerable to flooding and erosion of cap from overtopping
- Vulnerable to public health and safety exposure from erosion of cap

What is at Stake?

- Closure of park means loss of regional public open space
- Loss of required public access
- Impacts to the Health of community
- Impacts to the Health of Bay Habitat

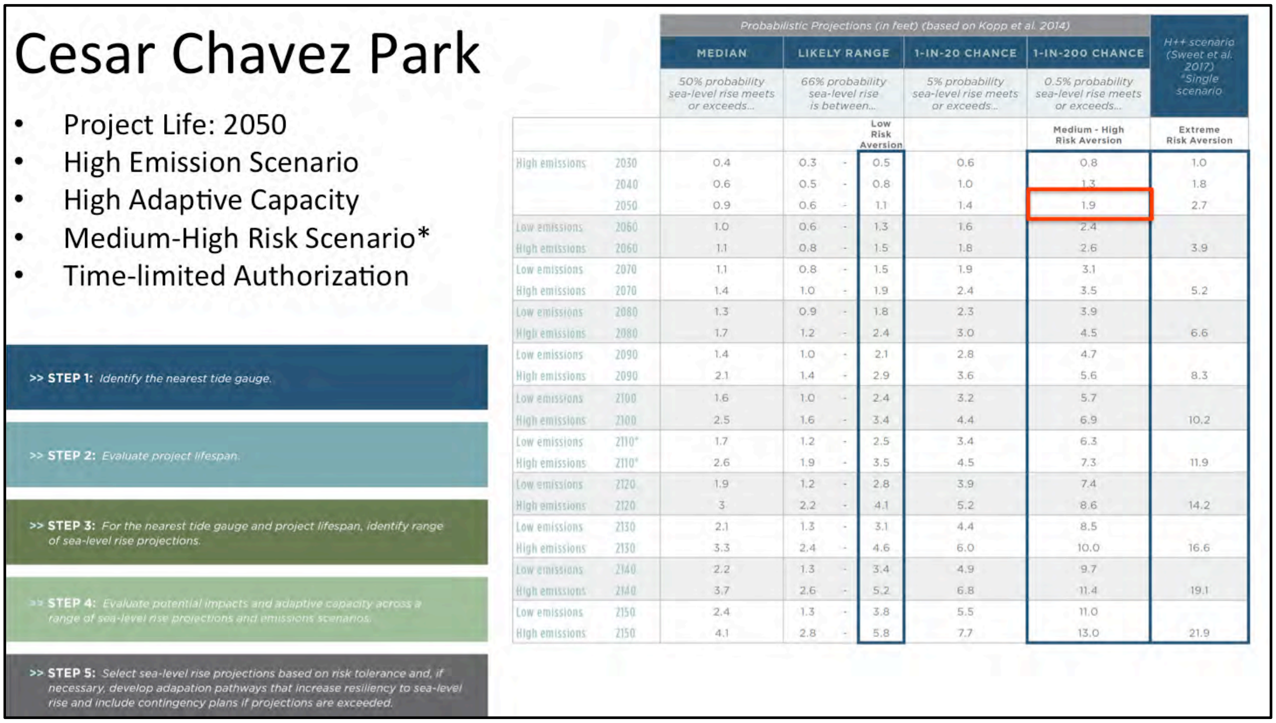
Adaptive Capacity

- There is Room to adapt! Yay!

Economic Impacts

- Costs associated with reconfiguring landfill to accommodate higher sea levels and park redesigns.
- Loss of revenue from events at Park and spillover economic benefits from regional park to local communities
- Public health impacts due to exposure from landfill contaminants – health insurance and loss of productivity

Since the project life ends at 2050, there is only a high emission scenario which made the analysis a little easier.



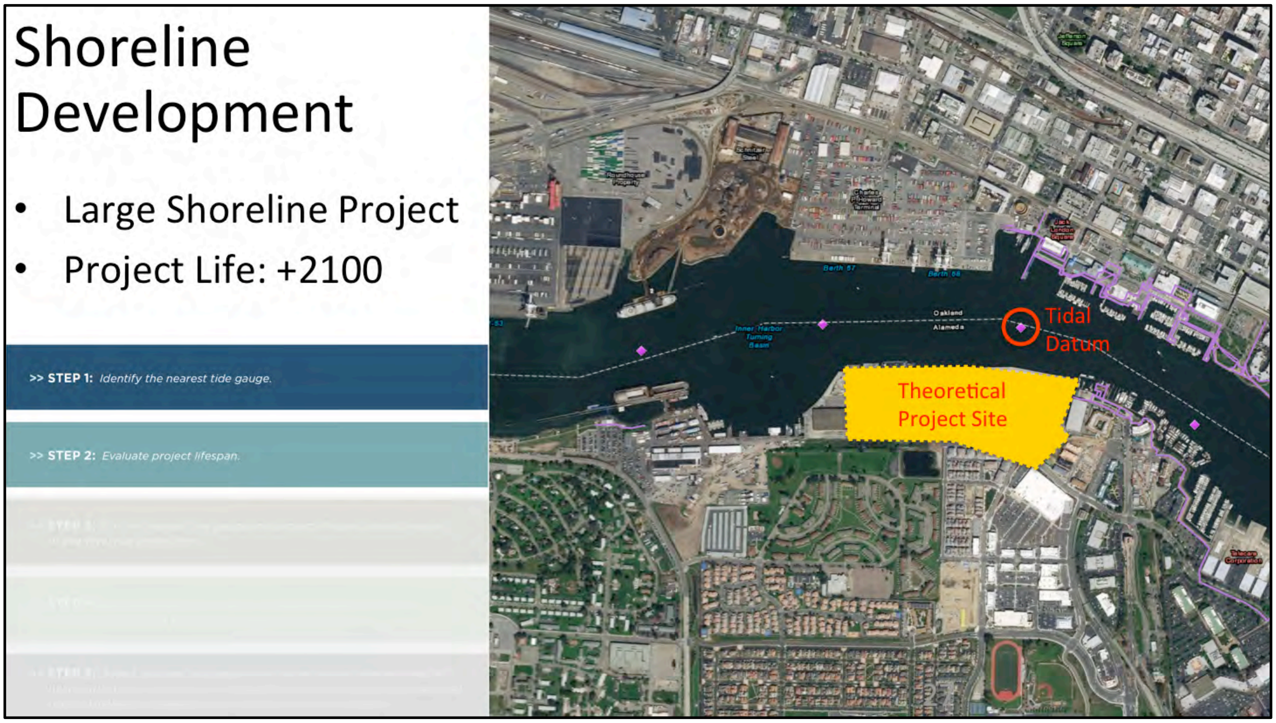
		Probabilistic Projections (in feet) (based on Kopp et al. 2014)						H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE			1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds...	66% probability sea-level rise is between...			5% probability sea-level rise meets or exceeds...	0.5% probability sea-level rise meets or exceeds...	
					Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.4	0.3	-	0.5	0.6	0.8	1.0
	2040	0.6	0.5	-	0.8	1.0	1.3	1.8
	2050	0.9	0.6	-	1.1	1.4	1.9	2.7
Low emissions	2060	1.0	0.6	-	1.3	1.6	2.4	
High emissions	2060	1.1	0.8	-	1.5	1.8	2.6	3.9
Low emissions	2070	1.1	0.8	-	1.5	1.9	3.1	
High emissions	2070	1.4	1.0	-	1.9	2.4	3.5	5.2
Low emissions	2080	1.3	0.9	-	1.8	2.3	3.9	
High emissions	2080	1.7	1.2	-	2.4	3.0	4.5	6.6
Low emissions	2090	1.4	1.0	-	2.1	2.8	4.7	
High emissions	2090	2.1	1.4	-	2.9	3.6	5.6	8.3
Low emissions	2100	1.6	1.0	-	2.4	3.2	5.7	
High emissions	2100	2.5	1.6	-	3.4	4.4	6.9	10.2
Low emissions	2110*	1.7	1.2	-	2.5	3.4	6.3	
High emissions	2110*	2.6	1.9	-	3.5	4.5	7.3	11.9
Low emissions	2120	1.9	1.2	-	2.8	3.9	7.4	
High emissions	2120	3	2.2	-	4.1	5.2	8.6	14.2
Low emissions	2130	2.1	1.3	-	3.1	4.4	8.5	
High emissions	2130	3.3	2.4	-	4.6	6.0	10.0	16.6
Low emissions	2140	2.2	1.3	-	3.4	4.9	9.7	
High emissions	2140	3.7	2.6	-	5.2	6.8	11.4	19.1
Low emissions	2150	2.4	1.3	-	3.8	5.5	11.0	
High emissions	2150	4.1	2.8	-	5.8	7.7	13.0	21.9

For the next step in the analysis we selected a specific sea level rise projection.

Since there is Room to adapt – a low risk aversion would be acceptable for the required public access.
However, the site is a capped solid waste landfill and the shoreline riprap is in place to prevent erosion of landfill cap. Overland flooding could potentially impact the safety of landfill materials from remaining contained.

For this reason, we found the low risk aversion scenario to be problematic given potential public safety impact from exposure of the landfill. So we applied the medium-high risk aversion scenario.

The medium-high risk scenario for mid-century sea level rise with a time-limited authorization addresses the risk tolerance and allows for future planning for sea level rise adaptation across the entire park site.
As you can see from the red lines, there are many locations where the shoreline will be overtopped with 24 inches of sea level rise during a 100 year storm event.



This next example is a theoretical larger shoreline development project analysis that you can expect to see for several projects coming to the Commission in the new year.

Ideally, the tidal datum is immediately adjacent to the project site.

For the larger shoreline Projects, the lifespan is typically expected through the end of the century given the proposed land uses.

Shoreline Development

- Large Shoreline Project
- Project Life: +2100

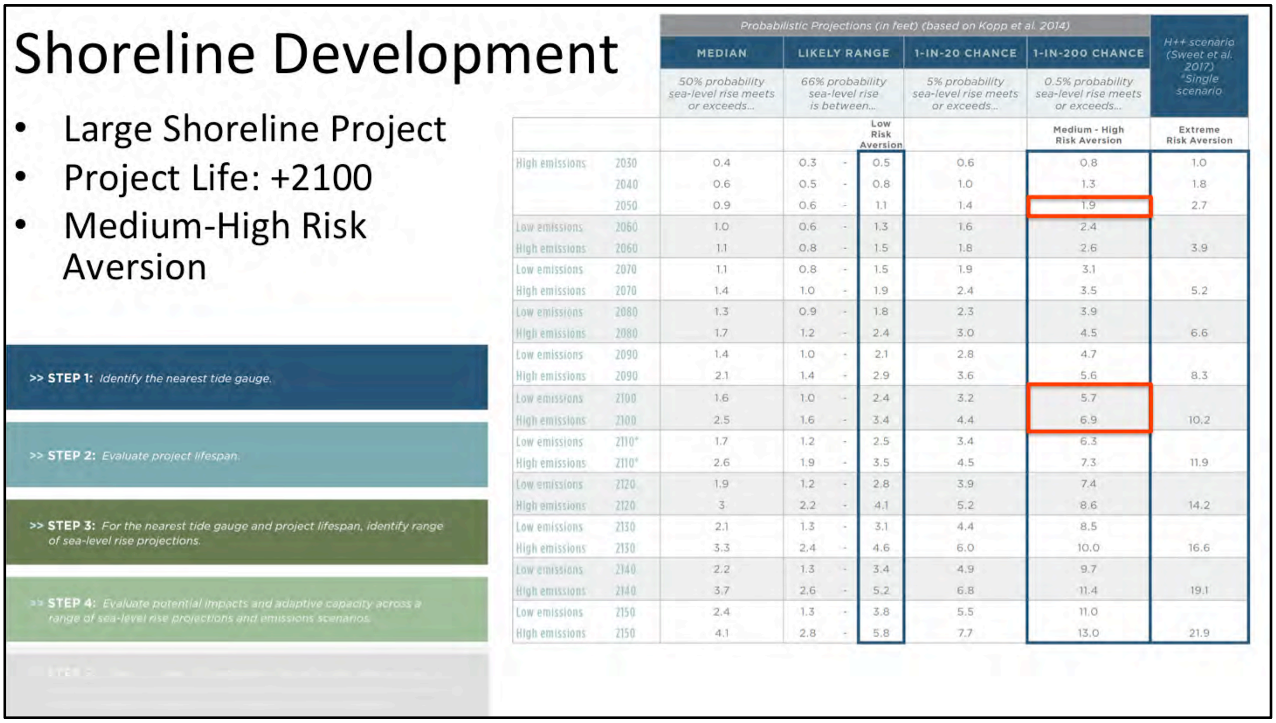
>> STEP 1: *Identify the nearest tide gauge.*

>> STEP 2: *Evaluate project lifespan.*

>> STEP 3: *For the nearest tide gauge and project lifespan, identify range of sea-level rise projections.*

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)						H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE			1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds...	66% probability sea-level rise is between...			5% probability sea-level rise meets or exceeds...	0.5% probability sea-level rise meets or exceeds...	
					Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.4	0.3	-	0.5	0.6	0.8	1.0
	2040	0.6	0.5	-	0.8	1.0	1.3	1.8
	2050	0.9	0.6	-	1.1	1.4	1.9	2.7
Low emissions	2060	1.0	0.6	-	1.3	1.6	2.4	
High emissions	2060	1.1	0.8	-	1.5	1.8	2.6	3.9
Low emissions	2070	1.1	0.8	-	1.5	1.9	3.1	
High emissions	2070	1.4	1.0	-	1.9	2.4	3.5	5.2
Low emissions	2080	1.3	0.9	-	1.8	2.3	3.9	
High emissions	2080	1.7	1.2	-	2.4	3.0	4.5	6.6
Low emissions	2090	1.4	1.0	-	2.1	2.8	4.7	
High emissions	2090	2.1	1.4	-	2.9	3.6	5.6	8.3
Low emissions	2100	1.6	1.0	-	2.4	3.2	5.7	
High emissions	2100	2.5	1.6	-	3.4	4.4	6.9	10.2
Low emissions	2110*	1.7	1.2	-	2.5	3.4	6.3	
High emissions	2110*	2.6	1.9	-	3.5	4.5	7.3	11.9
Low emissions	2120	1.9	1.2	-	2.8	3.9	7.4	
High emissions	2120	3	2.2	-	4.1	5.2	8.6	14.2
Low emissions	2130	2.1	1.3	-	3.1	4.4	8.5	
High emissions	2130	3.3	2.4	-	4.6	6.0	10.0	16.6
Low emissions	2140	2.2	1.3	-	3.4	4.9	9.7	
High emissions	2140	3.7	2.6	-	5.2	6.8	11.4	19.1
Low emissions	2150	2.4	1.3	-	3.8	5.5	11.0	
High emissions	2150	4.1	2.8	-	5.8	7.7	13.0	21.9

The next step identifies the range of sea level rise scenarios.
With shoreline development we are concerned with the mid-century resilience and end of century adaptive capacity of the public access that is required as a condition for the development.



		Probabilistic Projections (in feet) (based on Kopp et al. 2014)						H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE			1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds...	66% probability sea-level rise is between...			5% probability sea-level rise meets or exceeds...	0.5% probability sea-level rise meets or exceeds...	
					Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.4	0.3	-	0.5	0.6	0.8	1.0
	2040	0.6	0.5	-	0.8	1.0	1.3	1.8
	2050	0.9	0.6	-	1.1	1.4	1.9	2.7
Low emissions	2060	1.0	0.6	-	1.3	1.6	2.4	
High emissions	2060	1.1	0.8	-	1.5	1.8	2.6	3.9
Low emissions	2070	1.1	0.8	-	1.5	1.9	3.1	
High emissions	2070	1.4	1.0	-	1.9	2.4	3.5	5.2
Low emissions	2080	1.3	0.9	-	1.8	2.3	3.9	
High emissions	2080	1.7	1.2	-	2.4	3.0	4.5	6.6
Low emissions	2090	1.4	1.0	-	2.1	2.8	4.7	
High emissions	2090	2.1	1.4	-	2.9	3.6	5.6	8.3
Low emissions	2100	1.6	1.0	-	2.4	3.2	5.7	
High emissions	2100	2.5	1.6	-	3.4	4.4	6.9	10.2
Low emissions	2110*	1.7	1.2	-	2.5	3.4	6.3	
High emissions	2110*	2.6	1.9	-	3.5	4.5	7.3	11.9
Low emissions	2120	1.9	1.2	-	2.8	3.9	7.4	
High emissions	2120	3	2.2	-	4.1	5.2	8.6	14.2
Low emissions	2130	2.1	1.3	-	3.1	4.4	8.5	
High emissions	2130	3.3	2.4	-	4.6	6.0	10.0	16.6
Low emissions	2140	2.2	1.3	-	3.4	4.9	9.7	
High emissions	2140	3.7	2.6	-	5.2	6.8	11.4	19.1
Low emissions	2150	2.4	1.3	-	3.8	5.5	11.0	
High emissions	2150	4.1	2.8	-	5.8	7.7	13.0	21.9

For this example, we will consider a medium-high risk aversion because of the limitations of the adaptive capacity of the required public access.

Remember that Any public access provided as a condition of development within the shoreline band should:

- Either remain viable in the event of future sea level rise or flooding
- Or equivalent access consistent with the project should be provided nearby

As a reminder, the shoreline band jurisdiction is not a setback and we allow development within this area, but that can impact the adaptive capacity of the required public access and in turn require a higher risk aversion.
The next few slides will look at why we are considering Medium-High Risk and Why are we considering Low or High Emissions for the end of the century.

Proposed Project Flood Table

Promenade	13								
Upper Walk	14								
White cell shows freeboard in (##) feet	Curent Elevation in feet (NAVD88)			Projected Sea Level Rise (feet)	Year: *2050*		Projected Sea Level Rise (feet)	Year: *2100*	
Blue means asset is flooded by amount shown (-##) feet					Emissions Level: *High Emissions*			Emissions Level: *Low Emissions*	
					Risk Category: *Medium - High Risk*			Risk Category: *Medium - High Risk*	
	Water Level	**Promenade**	**Upper Walk**	**1.9**	**Promenade**	**Upper Walk**	**5.7**	**Promenade**	**Upper Walk**
Seasonal Water Level									
Mean lower low water (MLLW)	-0.10	13.10	14.10	1.80	11.20	12.20	5.60	7.40	8.40
Mean low water (MLW)	0.97	12.03	13.03	2.87	10.13	11.13	6.67	6.33	7.33
Mean tide level (MTL)	3.34	9.66	10.66	5.24	7.76	8.76	9.04	3.96	4.96
Mean sea level (MSL)	3.28	9.73	10.73	5.18	7.83	8.83	8.98	4.03	5.03
Mean high water (MHW)	5.70	7.30	8.30	7.60	5.40	6.40	11.40	1.60	2.60
Mean higher high water (MHHW)	6.28	6.72	7.72	8.18	4.82	5.82	11.98	1.02	2.02
Flood Event									
FEMA 1 year stillwater elevation (100%) (AKA King Tide)	7.54	5.46	6.46	9.44	3.56	4.56	13.24	-0.24	0.76
FEMA 2 year stillwater elevation (50%)	7.83	5.17	6.17	9.73	3.27	4.27	13.53	-0.53	0.47
FEMA 5 year stillwater elevation (20%)	8.21	4.79	5.79	10.11	2.89	3.89	13.91	-0.91	0.09
FEMA 10 year stillwater elevation (10%)	8.50	4.50	5.50	10.40	2.60	3.60	14.20	-1.20	-0.20
FEMA 25 year stillwater elevation (4%)	8.90	4.10	5.10	10.80	2.20	3.20	14.60	-1.60	-0.60
FEMA 50 year stillwater elevation (2%)	9.24	3.76	4.76	11.14	1.86	2.86	14.94	-1.94	-0.94
FEMA 100 year stillwater elevation (1%)	9.61	3.39	4.39	11.51	1.49	2.49	15.31	-2.31	-1.31
FEMA 500 year stillwater elevation (0.2%)	10.59	2.41	3.41	12.49	0.51	1.51	16.29	-3.29	-2.29
FEMA Base Flood Elevation (1%)	10.00	3.00	4.00	11.90	1.10	2.10	15.70	-2.70	-1.70

FEMA/AECOM2016 Tidal Datum Location ID: 561

Water Depth Color/Value Range
< 0
< -0.5
< -1
< -1.5
< -2
< -2.5
< -3
< -3.5
< -4
< -4.5
< -5
< -5.5
< -6
< -6.5
< -7
< -7.5
< -8

Orange value to be manually entered
Blue values are variable and are tied to formulas and conditional formatting in cells with black values/text
Revised May 3, 2018

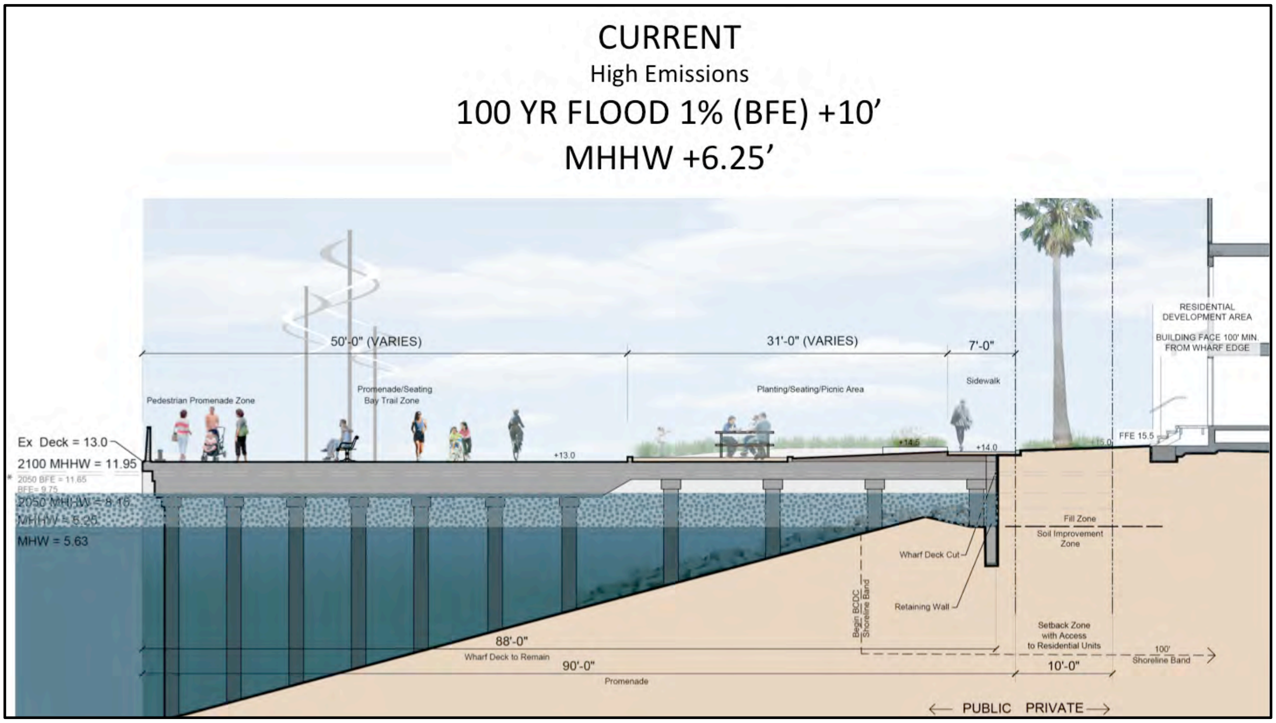
This is the updated version of the flood table tool we developed for the Hill Slough project that incorporates the OPC guidance.
We use the spreadsheet in coordination with the flood explorer and the tidal datums study to understand flooding impacts on future public access projects by adjusting existing grades to proposed grades to evaluate different project lifespans, risk categories, and emissions scenarios.

Here's what we built into the spreadsheet.

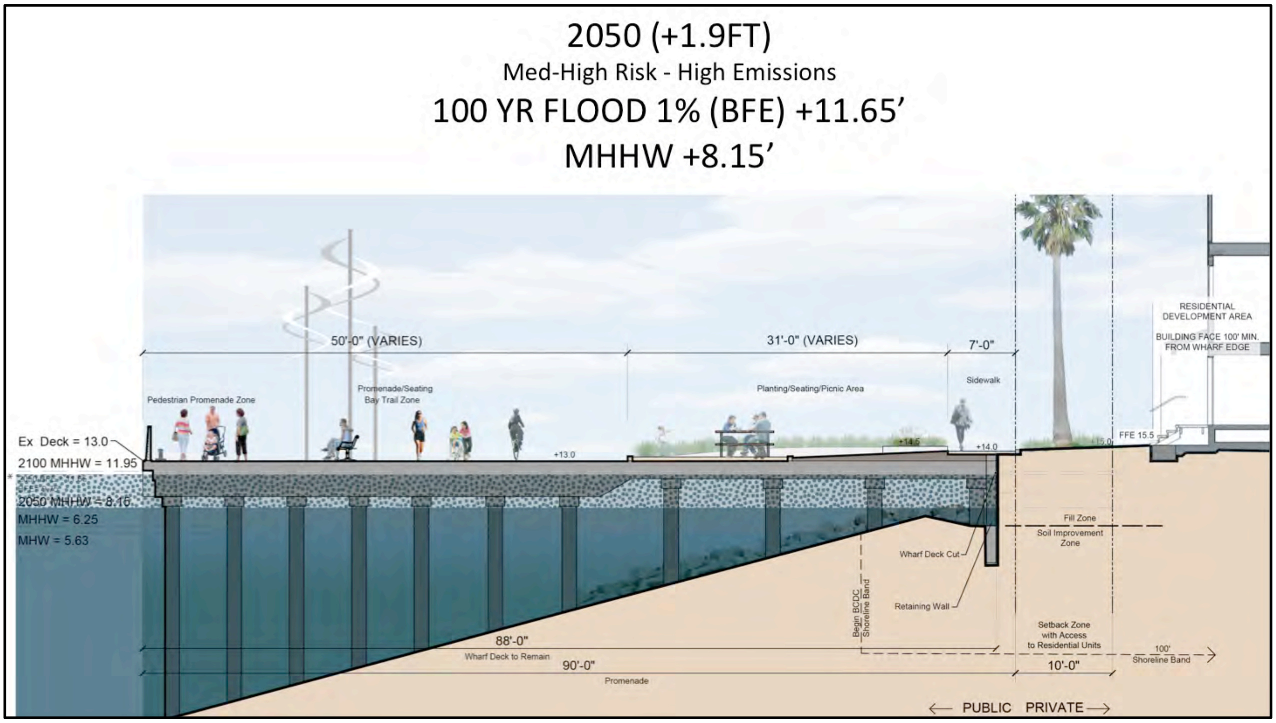
- Proposed Improvements and Proposed Elevation
- Current and future water elevations for daily tides and extreme tide flood events.
- Emissions levels and risk aversions.
- We updated the blue to express a gradient of water depth where the blue cell indicates how much water will cover the area.

As you can see in this example the Proposed Public Access is resilient through Mid-Century and will only begin to flood at the end of century with higher high tides, which happen about once a month.

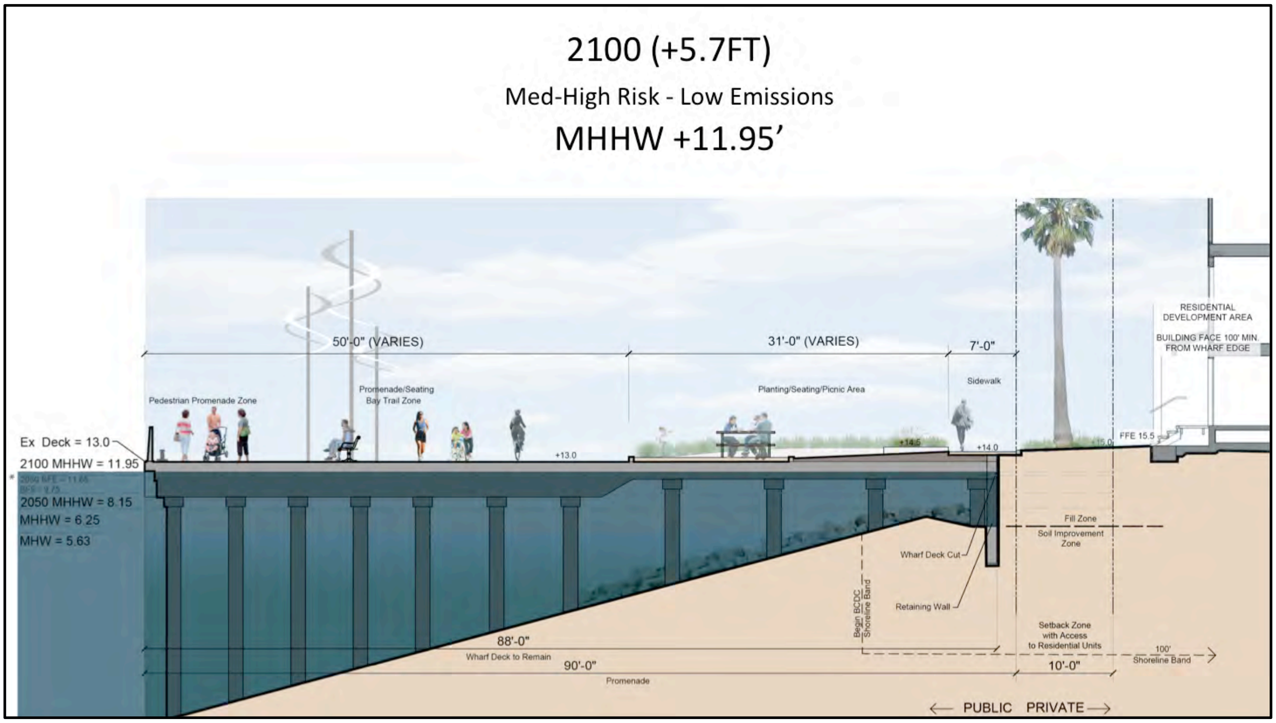
Next I'll walk you through a series of cross sections of the proposed public access area to visualize what these numbers look like in the physical landscape. These are typical cross sections used for project review by the DRB and the ECRB and are also often included in the risk assessments for larger shoreline development projects.



This section shows Current water levels, mean higher high water and the 100-year storm on top of MHHW.
You can see this public access area is built on an existing wharf and there are buildings within the shoreline band.



Mid-century sea level rise elevation for the medium-high risk aversion with high carbon emissions scenario.
Flooding will reach the under side of wharf which may require additional maintenance, which is a factor to consider in the risk analysis. This is also the same water level as the low-risk aversion for 2070.

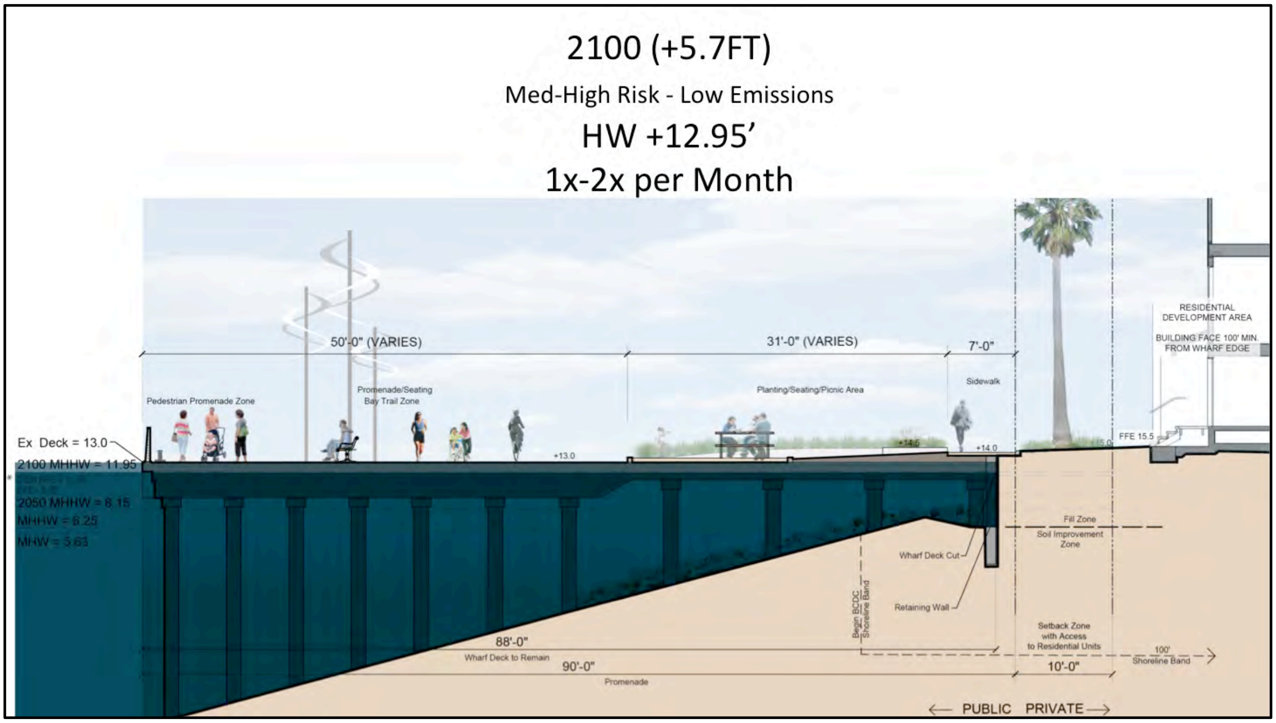


This section shows mean higher high water level associated with 5.7 feet of sea level rise, the low emissions scenario for the end of the century.

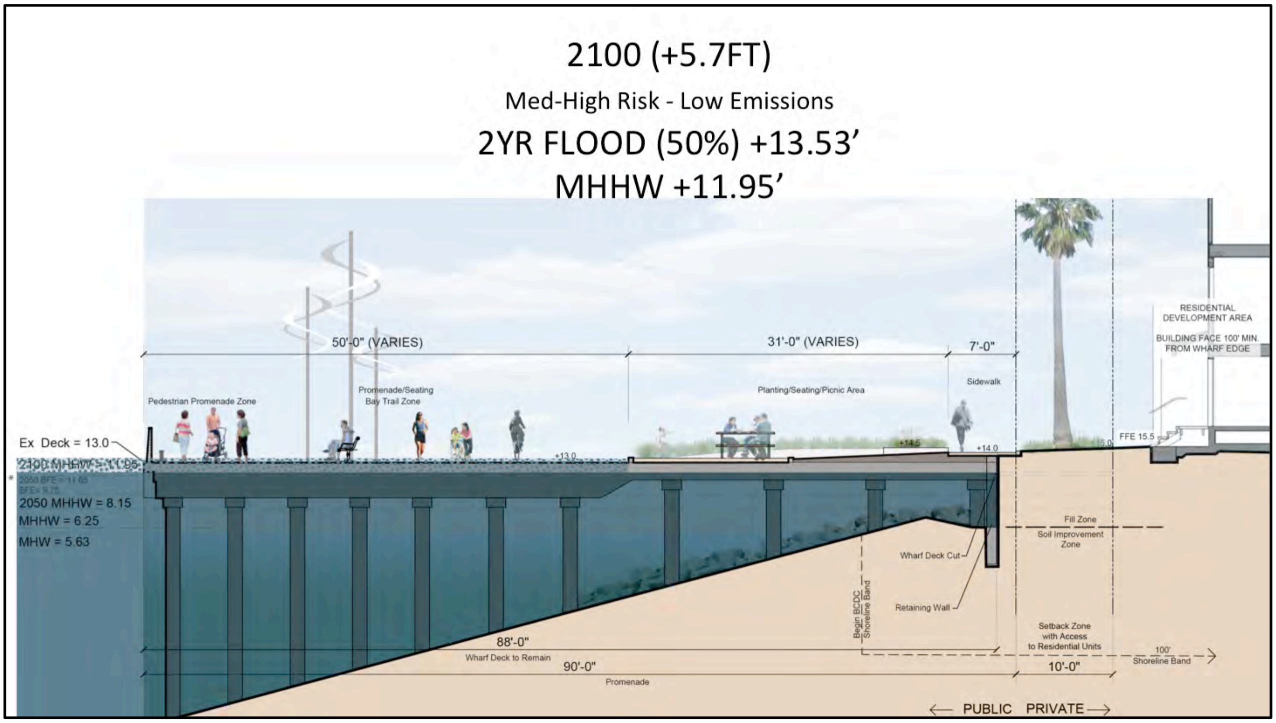
As you can see, the water comes close to the top of the wharf, but does not overtop it at MHHW.

This sea level rise scenario represents a 0.5% probability that sea level meets or exceeds 5.7 feet above current levels by the end of the century.

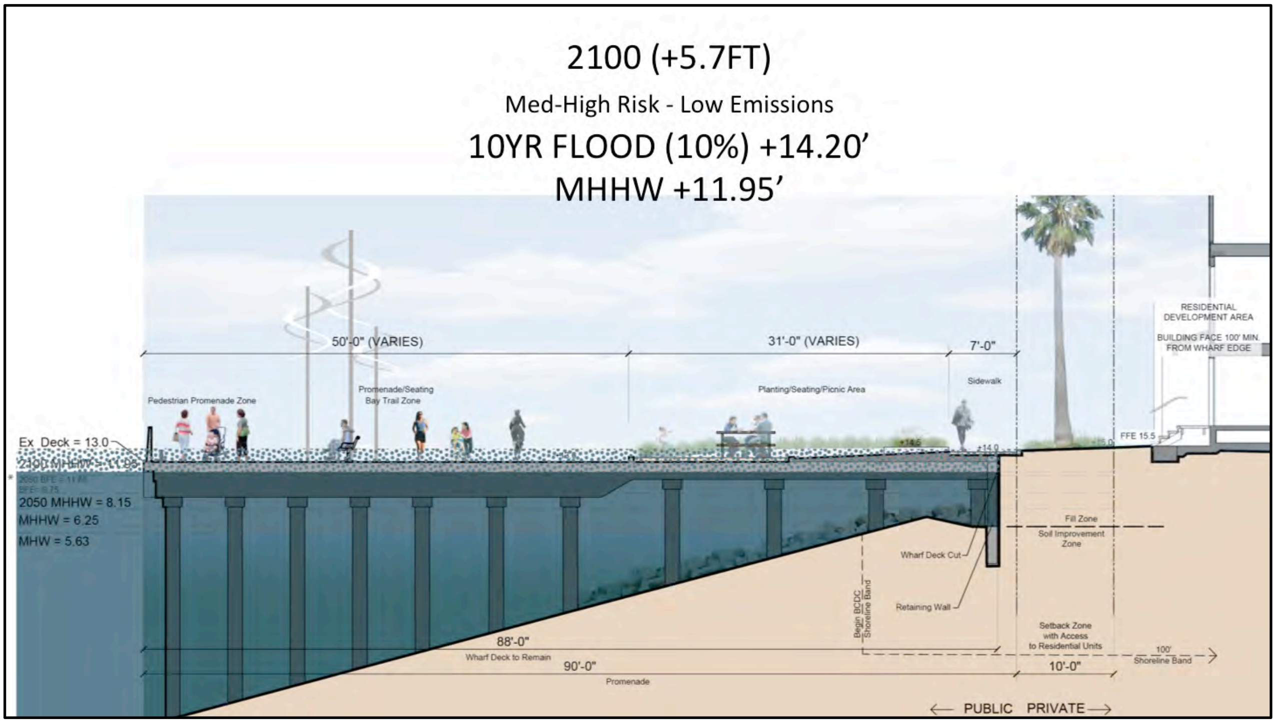
With that in mind, we want to show you the following scenarios which represent probable intermittent flooding associated with 5.7 feet of sea level rise.



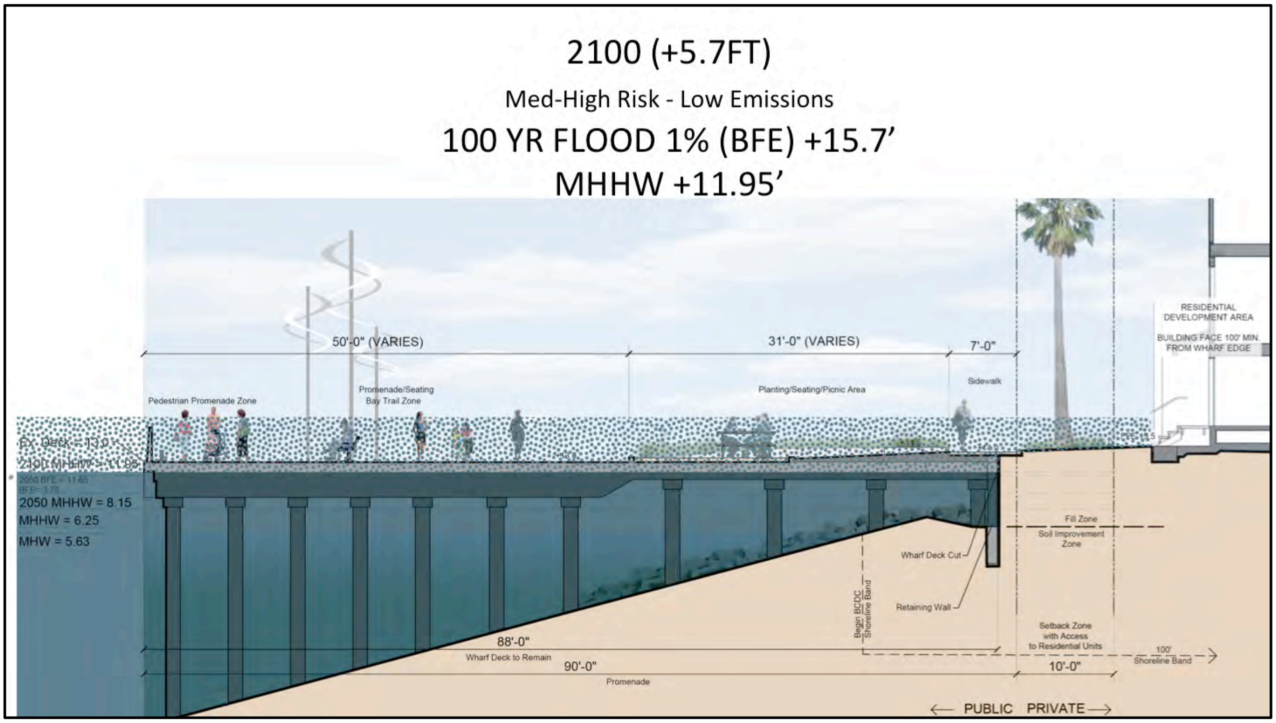
High Water tides occur on the new moon and full moon, usually twice a month. These water levels may cause some flooding of the proposed public access areas.



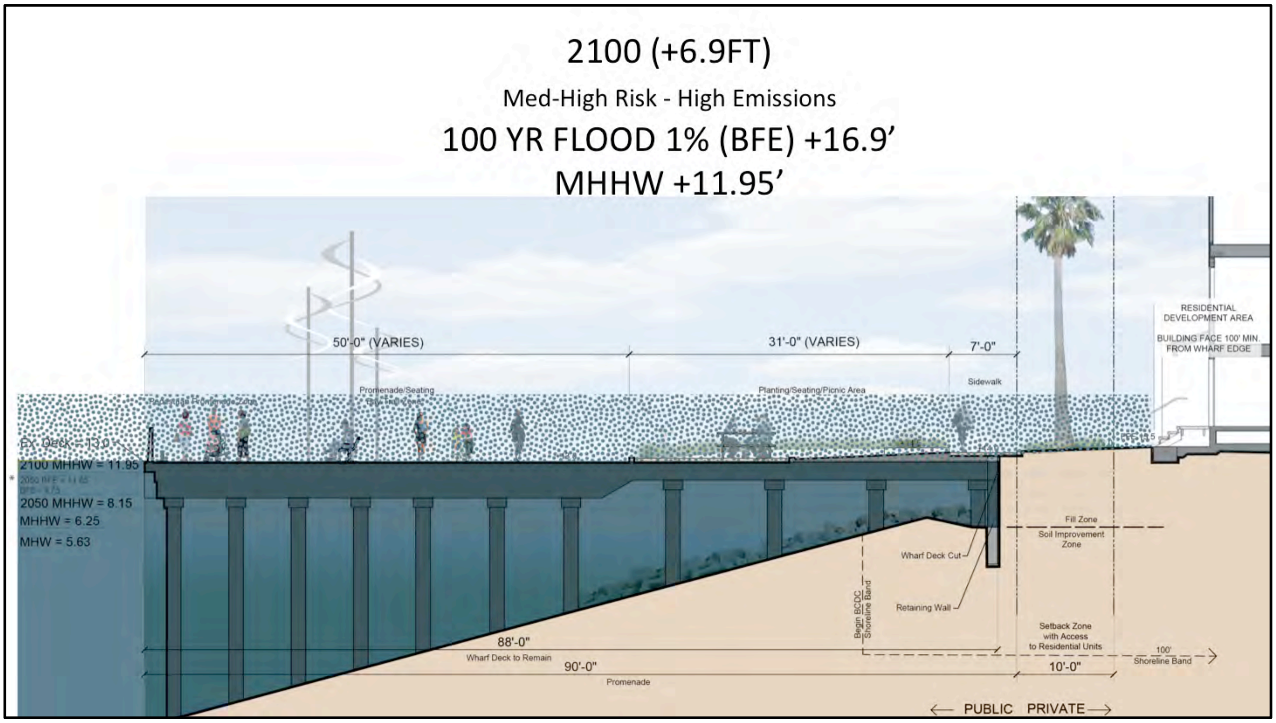
The 2 year flood event would likely flood a portion of the public access. The waters between two and six inches deep would likely discourage people from using the public access area as long as the water was present.



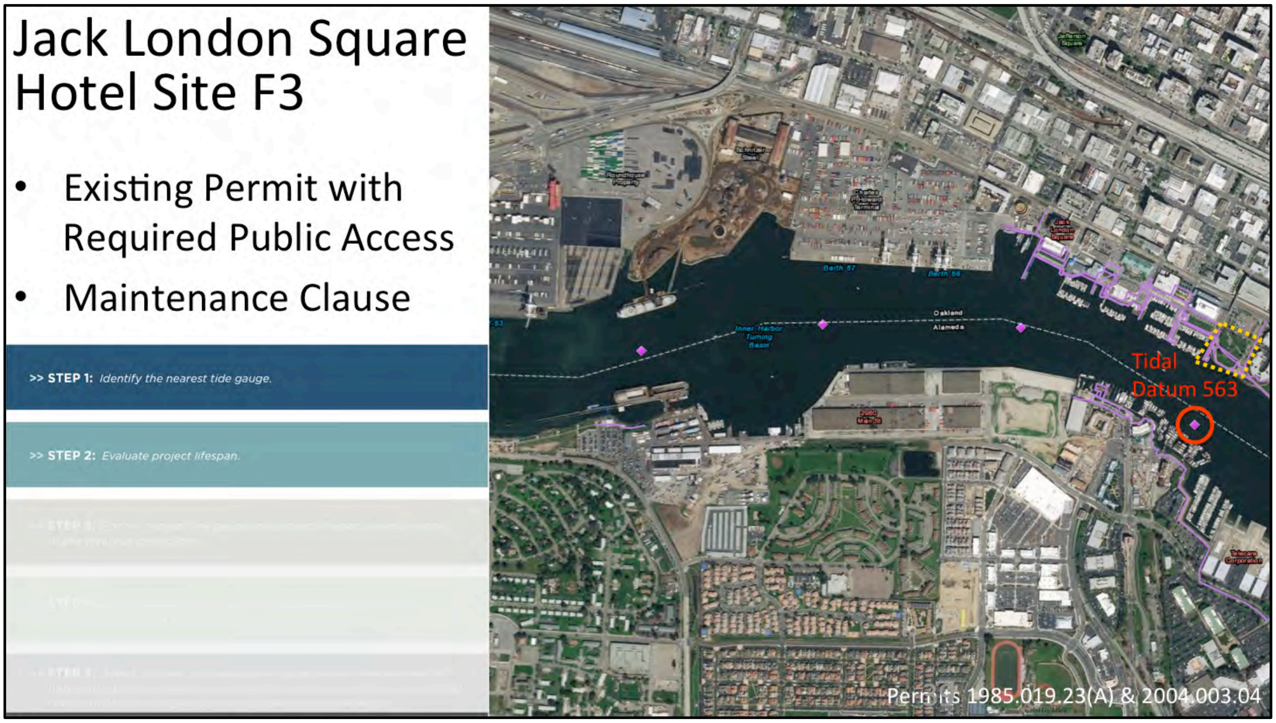
A 10 year flood event would flood most of the public access area with a water depth greater than one foot. The public access area would need to be closed to the public for safety reasons until the waters receded. An inspection of the public access would be prudent to determine if any damage occurred from the flooding.



The 100 year flood event would bring a significant amount of water to the public access area, flooding it entirely with more than 30 inches of water.
So, you may wonder why did we choose the Low Emissions scneario?
Well, we want to be optimistic, but we also recognize that either way you look at it, it’s a lot of water in a very distant future.
For High Emissions at 2090, the water elevation is projected for 5.6’ which is roughly equivalent to the end of century low emissions scenario. Meaning adaptation may need to begin a decade sooner if water levels reach these projections.



Here’s the high emissions scenario for end of century.
it’s a lot of water in a very distant future for which our policies only mandate an adaptive management plan should be developed to address the long-term impacts that will arise based on a risk assessment using the best available science-based projection for sea level rise at the end of the century. We are hopeful that the science of climate change available in 30-50 years will be as advanced as we have shifted in the past, and at which time we can appropriately address how to adapt our shoreline.



This final example is at Jack London Square which is a large shoreline development project that was permitted in 1986 with an additional permit added in 2004 to provide for more development including this hotel site next to the estuary green.
Given that both of the permits that govern this project site were issued prior to the climate change policies, there is no language about resilience or adaptation, so we will rely on the maintenance condition for public access in the permit which states:

“The areas and improvements within the … public access area … shall be permanently maintained by and at the expense of the permittees or their assignees.”

The DRB reviewed the proposed hotel project earlier this month (November 2018) per direction of the permit.
Considering the maintenance requirement for the public access, we asked the permittees about the resilience and adaptive capacity of the proposed public access and conducted the five-step analysis outlined by the OPC. The project proponents decided to take a pro-active approach to sea level rise with the hope of reducing the cost of future maintenance for the public access and the development.

As you can see, there is a tidal datum directly in front of the project site on the Oakland estuary.

It’s assumed that the permitted project will exist at the end of the century, so we used this for our analysis.

This is the proposed hotel plan and required shoreline public access at estuary green.

Jack London Square Hotel Site F3

- Existing Permit with Required Public Access & Maintenance Clause
- Project Life: 2100

>> STEP 1: *Identify the nearest tide gauge.*

>> STEP 2: *Evaluate project lifespan.*

>> STEP 3: *For the nearest tide gauge and project lifespan, identify range of sea-level rise projections.*

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)					H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE		1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds...	66% probability sea-level rise is between...		5% probability sea-level rise meets or exceeds...	0.5% probability sea-level rise meets or exceeds...	
				Low Risk Aversion		Medium - High Risk Aversion	Extreme Risk Aversion
High emissions	2030	0.4	0.3 -	0.5	0.6	0.8	1.0
	2040	0.6	0.5 -	0.8	1.0	1.3	1.8
	2050	0.9	0.6 -	1.1	1.4	1.9	2.7
Low emissions	2060	1.0	0.6 -	1.3	1.6	2.4	
High emissions	2060	1.1	0.8 -	1.5	1.8	2.6	3.9
Low emissions	2070	1.1	0.8 -	1.5	1.9	3.1	
High emissions	2070	1.4	1.0 -	1.9	2.4	3.5	5.2
Low emissions	2080	1.3	0.9 -	1.8	2.3	3.9	
High emissions	2080	1.7	1.2 -	2.4	3.0	4.5	6.6
Low emissions	2090	1.4	1.0 -	2.1	2.8	4.7	
High emissions	2090	2.1	1.4 -	2.9	3.6	5.6	8.3
Low emissions	2100	1.6	1.0 -	2.4	3.2	5.7	
High emissions	2100	2.5	1.6 -	3.4	4.4	6.9	10.2
Low emissions	2110*	1.7	1.2 -	2.5	3.4	6.3	
High emissions	2110*	2.6	1.9 -	3.5	4.5	7.3	11.9
Low emissions	2120	1.9	1.2 -	2.8	3.9	7.4	
High emissions	2120	3	2.2 -	4.1	5.2	8.6	14.2
Low emissions	2130	2.1	1.3 -	3.1	4.4	8.5	
High emissions	2130	3.3	2.4 -	4.6	6.0	10.0	16.6
Low emissions	2140	2.2	1.3 -	3.4	4.9	9.7	
High emissions	2140	3.7	2.6 -	5.2	6.8	11.4	19.1
Low emissions	2150	2.4	1.3 -	3.8	5.5	11.0	
High emissions	2150	4.1	2.8 -	5.8	7.7	13.0	21.9

After establishing the tidal datum and project life, we identified a range of sea level rise scenarios at which we arrived at medium-high risk aversion and the high emissions scenario.

Jack London Square Hotel Site F3

Jack London Square Hotel Sea Level Projected Impacts

Bay Trail	11	
Water Street	12	

White cell shows freeboard in (##) feet / Blue means asset is flooded by amount shown (-##) feet	Curent Elevation in feet (NAVD88)			Projected Sea Level Rise (feet)	Year: 2050 / Emissions Level: High Emissions / Risk Category: Medium - High Risk		Projected Sea Level Rise (feet)	Year: 2100 / Emissions Level: High Emissions / Risk Category: Medium - High Risk	
	Water Level	Bay Trail	Water Street	1.9	Bay Trail	Water Street	6.9	Bay Trail	Water Street
Seasonal Water Level									
Mean lower low water (MLLW)	-0.11	11.11	12.11	1.79	9.21	10.21	6.79	4.21	5.21
Mean low water (MLW)	0.97	10.03	11.03	2.87	8.13	9.13	7.87	3.13	4.13
Mean tide level (MTL)	3.34	7.66	8.66	5.24	5.76	6.76	10.24	0.76	1.76
Mean sea level (MSL)	3.28	7.72	8.72	5.18	5.82	6.82	10.18	0.82	1.82
Mean high water (MHW)	5.71	5.29	6.29	7.61	3.39	4.39	12.61	-1.61	-0.61
Mean higher high water (MHHW)	6.28	4.72	5.72	8.18	2.82	3.82	13.18	-2.18	-1.18
Flood Event									
FEMA 1 year stillwater elevation (100%) (AKA King Tide)	7.55	3.45	4.45	9.45	1.55	2.55	14.45	-3.45	-2.45
FEMA 2 year stillwater elevation (50%)	7.83	3.17	4.17	9.73	1.27	2.27	14.73	-3.73	-2.73
FEMA 5 year stillwater elevation (20%)	8.22	2.78	3.78	10.12	0.88	1.88	15.12	-4.12	-3.12
FEMA 10 year stillwater elevation (10%)	8.50	2.50	3.50	10.40	0.60	1.60	15.40	-4.40	-3.40
FEMA 25 year stillwater elevation (4%)	8.91	2.09	3.09	10.81	0.19	1.19	15.81	-4.81	-3.81
FEMA 50 year stillwater elevation (2%)	9.24	1.76	2.76	11.14	-0.14	0.86	16.14	-5.14	-4.14
FEMA 100 year stillwater elevation (1%)	9.60	1.40	2.40	11.50	-0.50	0.50	16.50	-5.50	-4.50
FEMA 500 year stillwater elevation (0.2%)	10.57	0.43	1.43	12.47	-1.47	-0.47	17.47	-6.47	-5.47
FEMA Base Flood Elevation (1%)	10.00	1.00	2.00	11.90	-0.90	0.10	16.90	-5.90	-4.90

FEMA/AECOM2016 Tidal Datum Location ID: 562

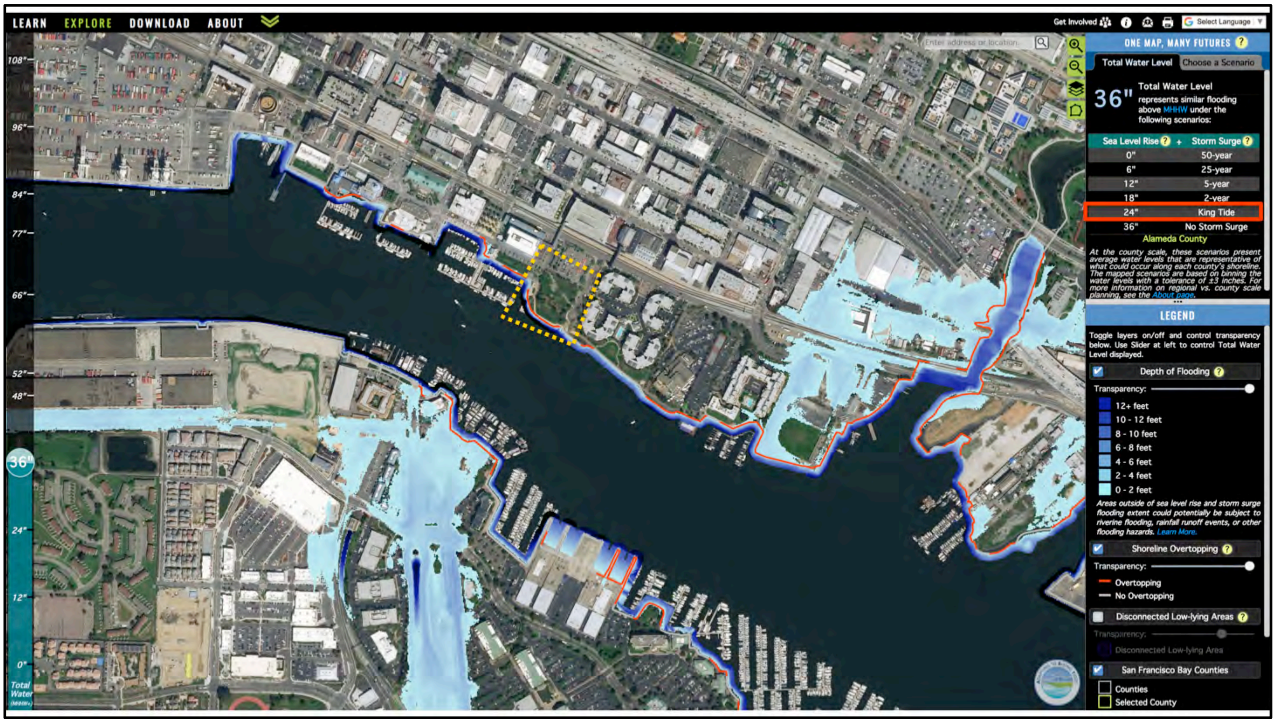
Water Depth Color/Value Range
< 0
< -0.5
< -1
< -1.5
< -2
< -2.5
< -3
< -3.5
< -4
< -4.5
< -5
< -5.5
< -6
< -6.5
< -7
< -7.5
< -8

Orange value to be manually entered
Blue values are variable and are tied to formulas and conditional formatting in cells with black values/text
Revised May 3, 2018

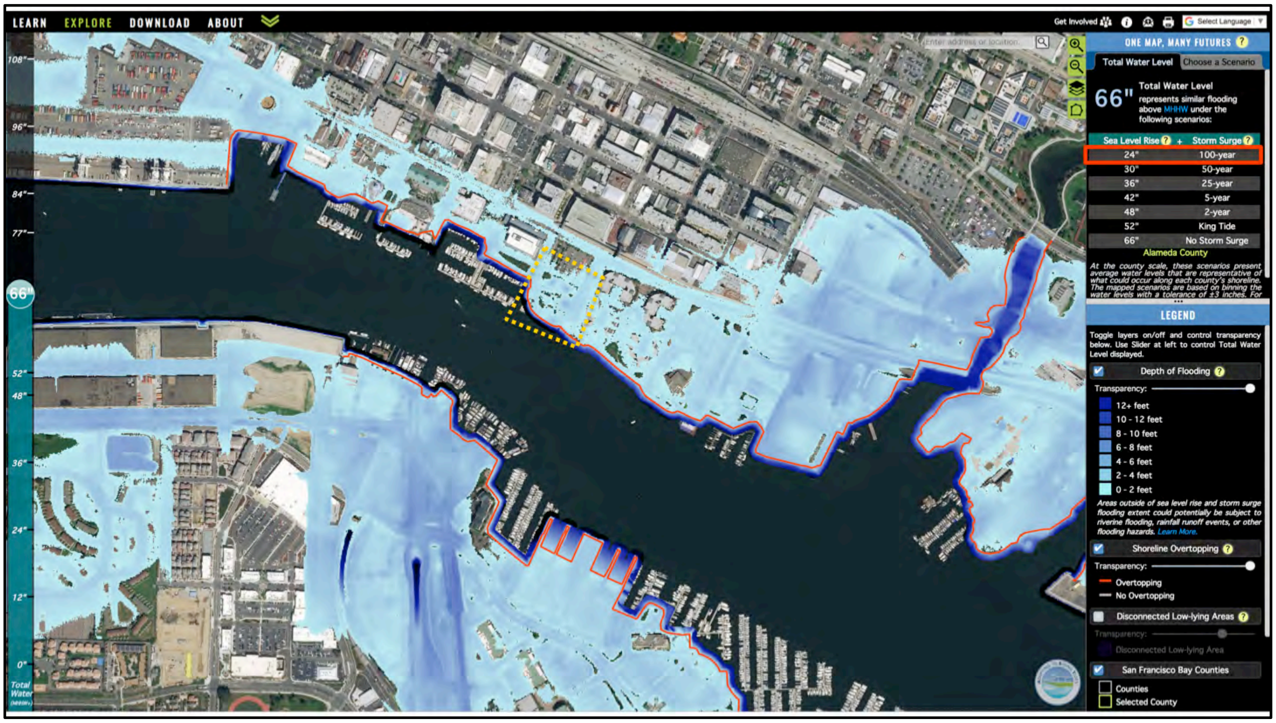
Why Medium-High Risk?
The Maintenance requirement of existing permit requires access to be there and be maintained.
No equivalent access is able to be provided nearby. The site will only slightly modify existing grades to match the grade at the rest of Jack London Square. Because of this we can use the flood explorer to understand the extent of flooding across the area.

Why High Emissions? Showing worst case scenario to understand adaptation possibilities

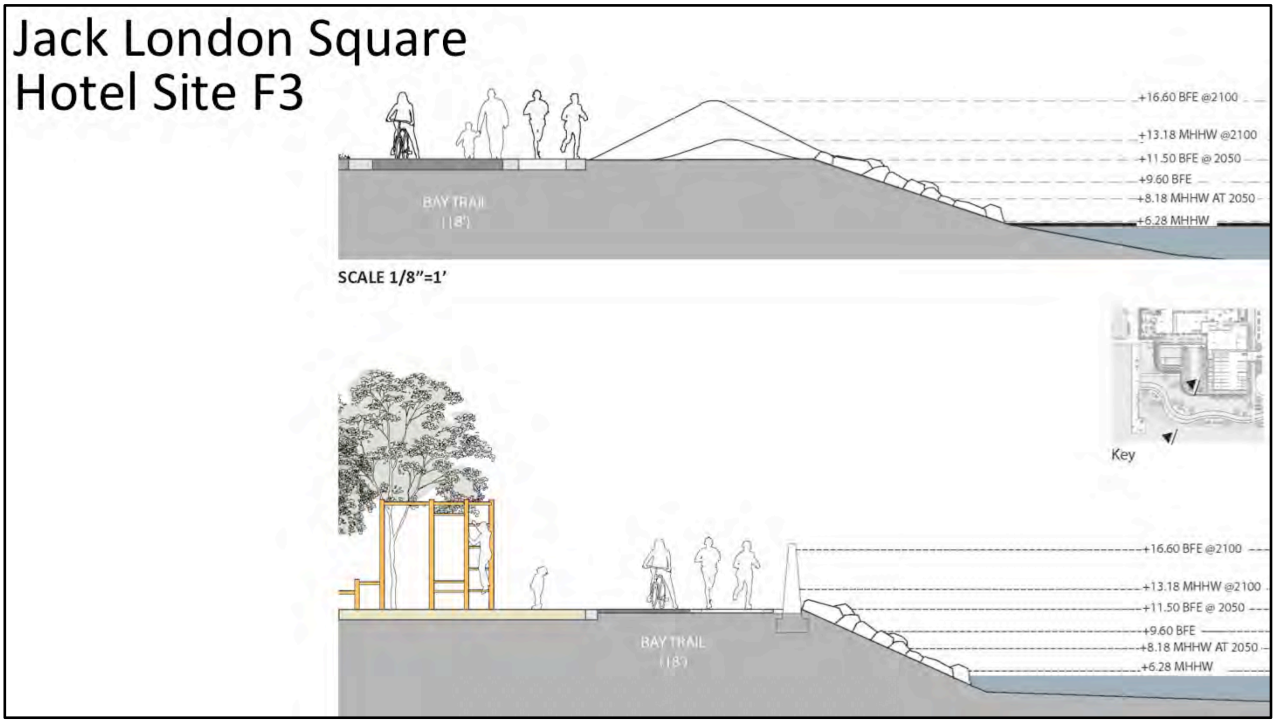
The flood table shows that the public access is Resilient to mid-century daily tidal fluctuations, but will likely flood with certain storms.
The End of century scenario shows daily flooding.



Here’s what the flooding looks like in the flood explorer
This water level is Roughly equivalent to mid-century sea level rise king tide event with the red indicating shoreline overtopping. The project site is outlined with an orange dashed line.

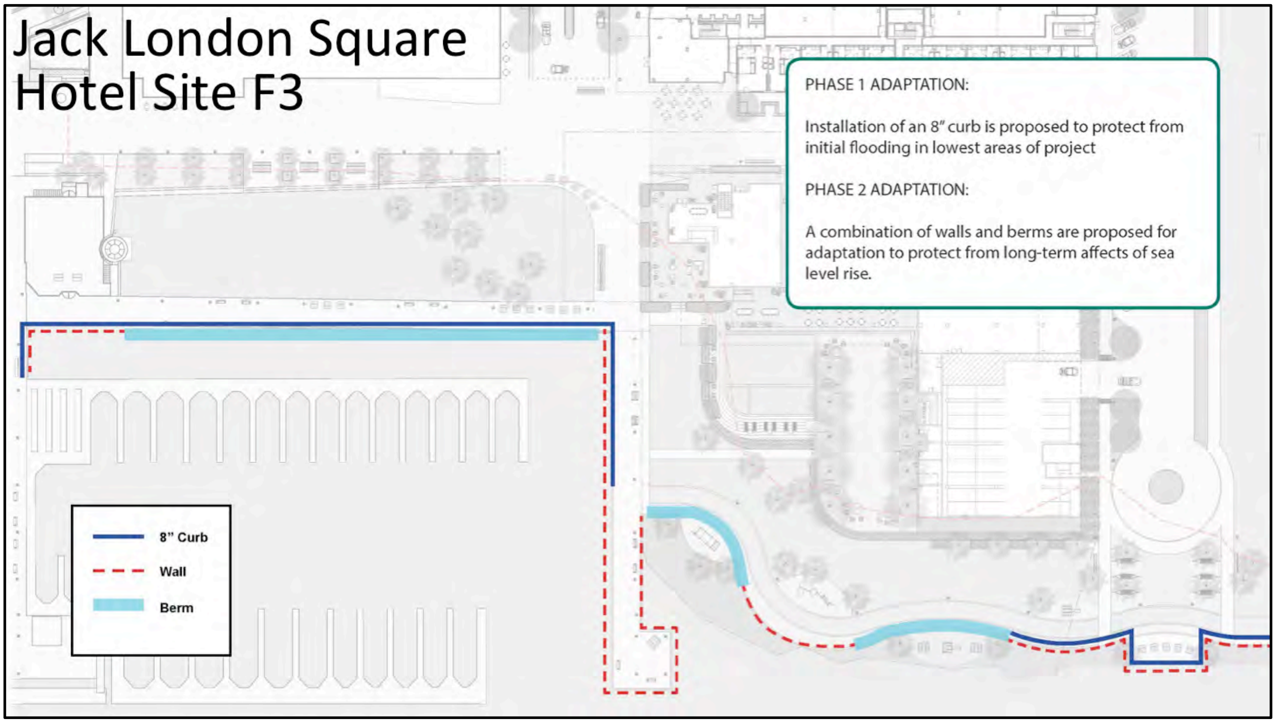


24 inches of SLR with a 100 year storm.
The Site will be flooded along with adjacent flooding that may impact the site.
It’s worth noting that All adjacent properties have similar maintenance conditions in their permits.



As part of the DRB review we asked how the project can be resilient to mid-century and adaptable to end of century sea levels.
These cross sections and the next slide show some possible design solutions to address future flooding, but should not be considered prescriptive solutions, but are merely demonstrating possible solutions to future water levels given our current knowledge about flooding and construction.

Fun Fact!
The developer used the flood explorer to study the sea level rise impacts and adjusted the finish floor elevation of the hotel to a higher grade.

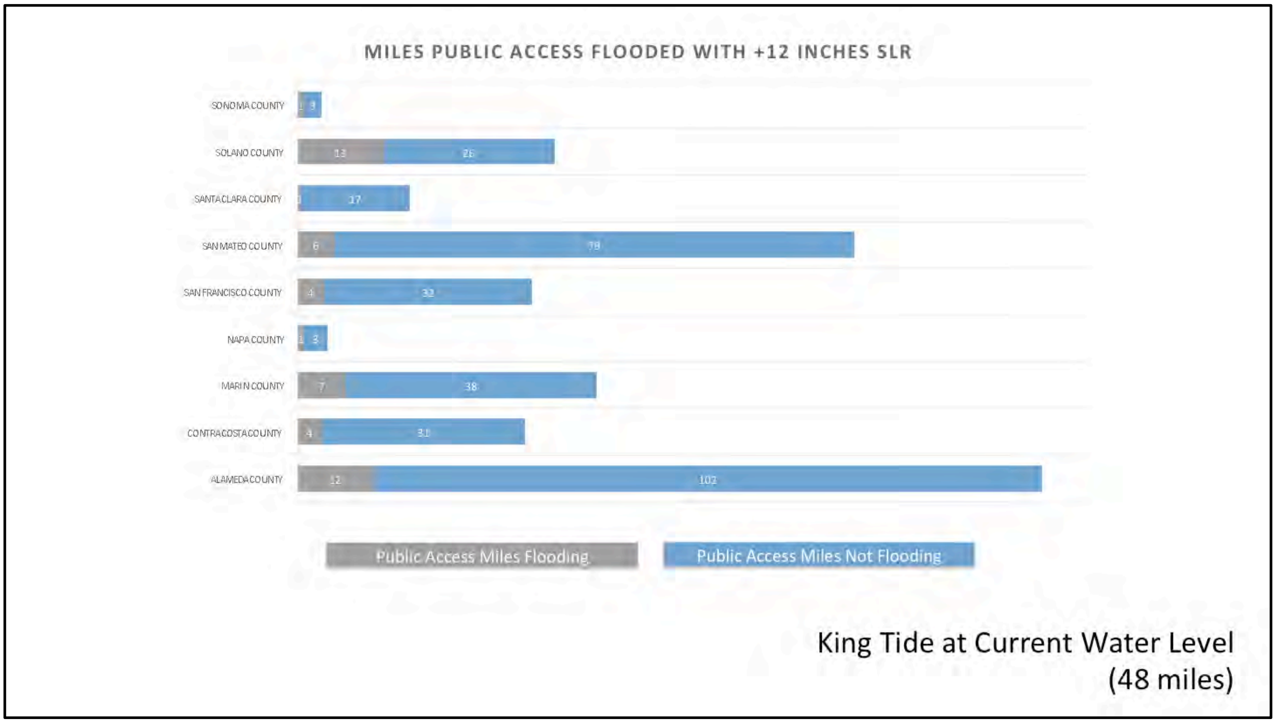


The adaptation approaches were considered in phases for incremental protection. Ultimately, the maintenance of the public access areas is a compliance and enforcement action upheld by the maintenance condition for the public access. We are showing you this project because these permit holders are being proactive in planning for future flooding. These exhibits will be part of the permit record and will hopefully be informative at such time that adaptation will be needed, but again, are not meant to be prescriptive solutions.

To build on this issue of maintenance conditions in existing permits and impacts from flooding, the planning staff used BayRAT, our internal GIS database viewer to make some rough calculations about future impacts to shoreline public access across the Bay Area.

The purple lines are rough representations of public access related to existing permits, and represent approximately 377 miles of access. As a reminder, the Bay Trail plans for about 500 miles of trails. This analysis is only an example of the potential impacts.

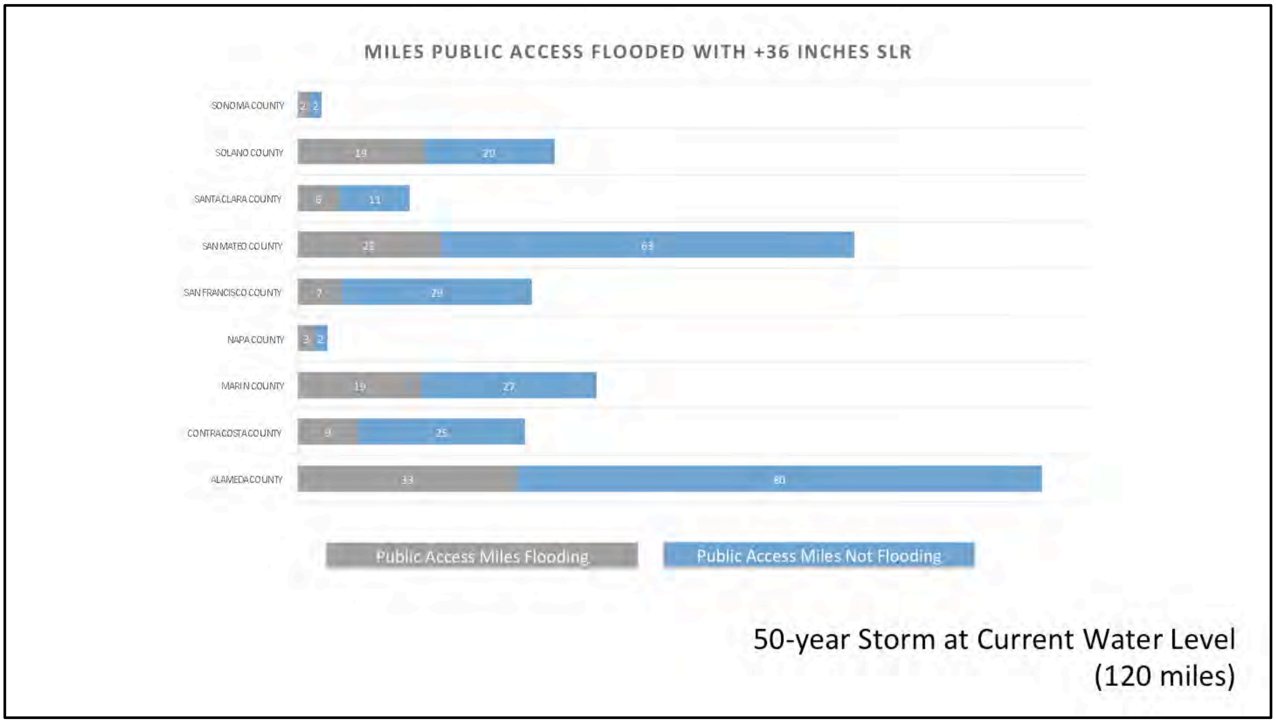
So let's look at several sea level rise scenarios and see what are the flooding impacts to this public access.



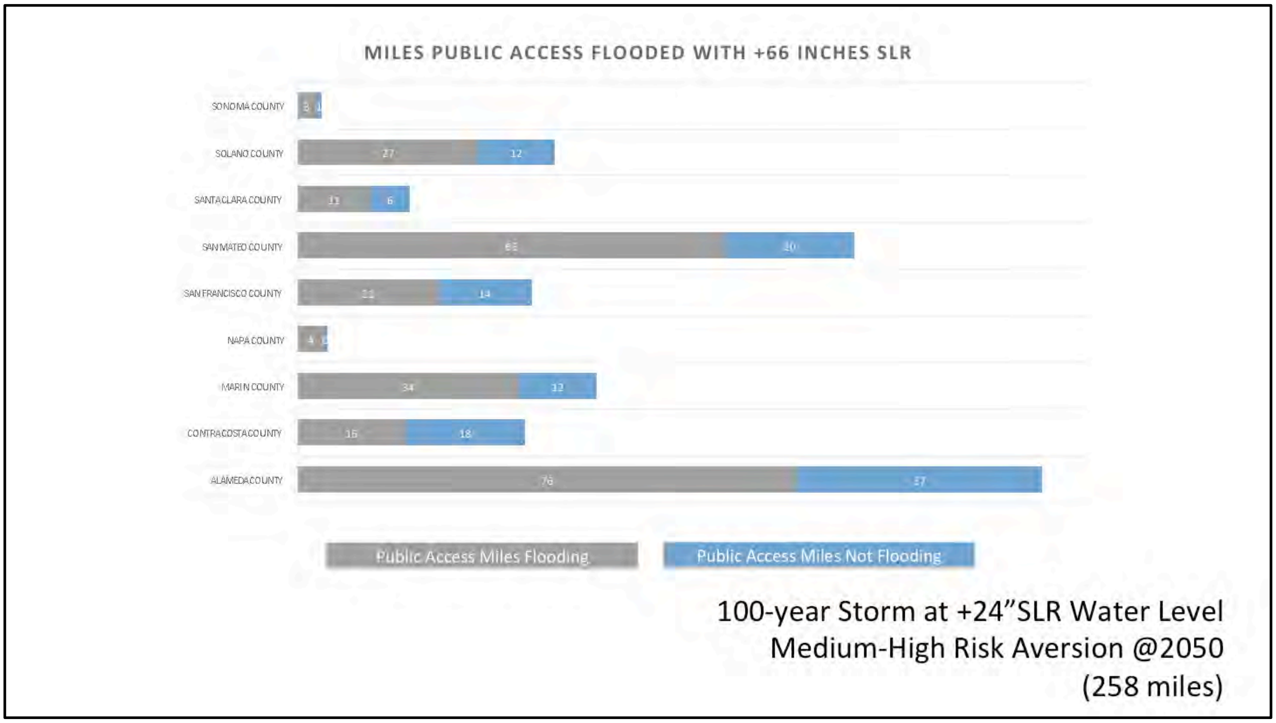
Note one map many futures scenarios…

With 12 inches of water, we see that about 48 miles of public access is flooded across the 9 counties.

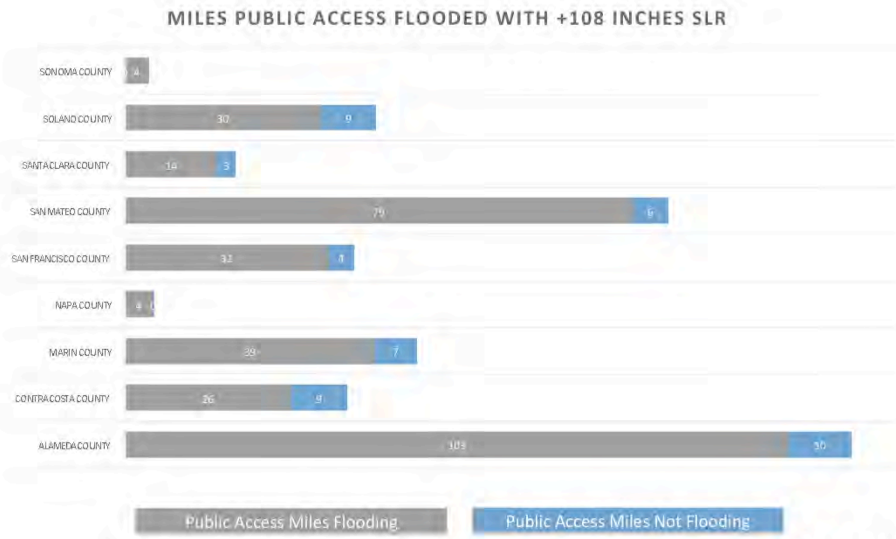
As a reminder, 12 inches of sea level rise is equivalent to a King Tide at current water levels.



At 36 inches of sea level rise, 120 miles of access becomes flooded. This is equivalent to a 50 year storm at current water levels.



Ok. Big jump!
At 66 inches of sea level rise, 258 miles of access becomes flooded, or roughly 65 percent of the shoreline public access experiences flooding. This is equivalent to a 100 year storm with 24 inches of sea level rise. This water level is roughly equivalent to the mid-century medium-high risk aversion water level.

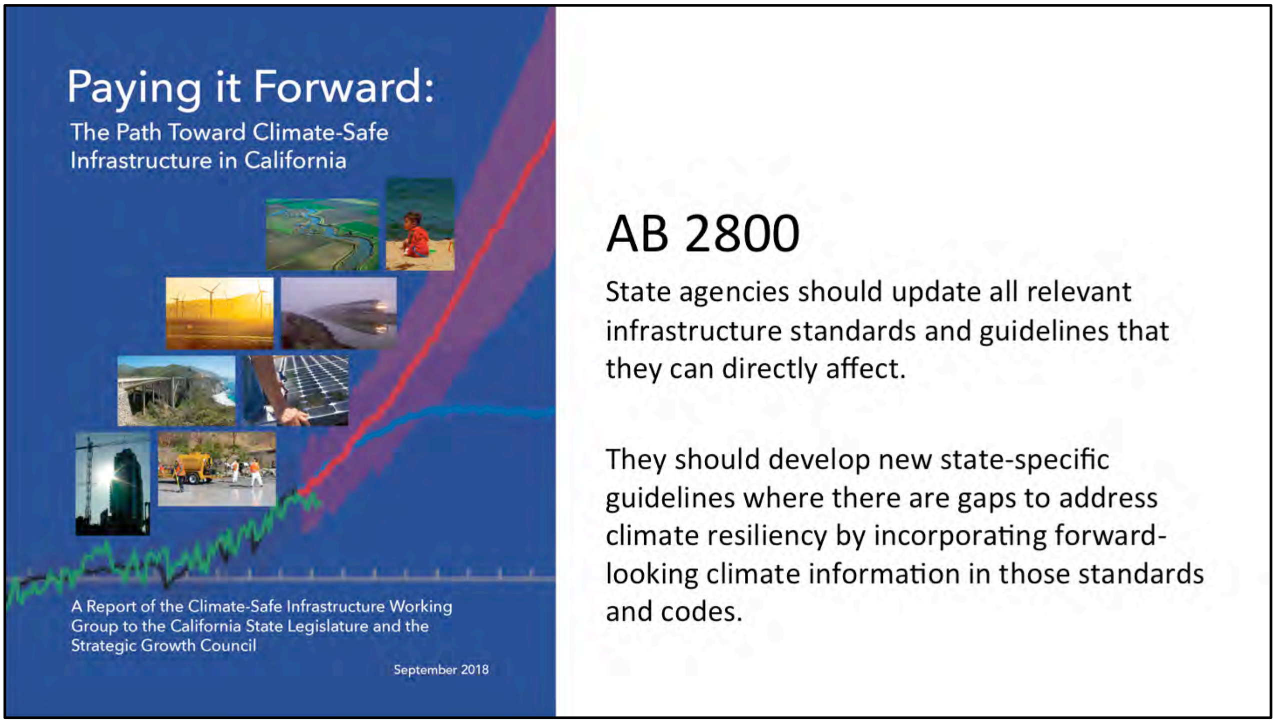


100-year Storm at +66"SLR Water Level
Medium-High Risk Aversion @ 2100
(331 miles)

And we reach the end of our flood explorer water levels...
At 108 inches of sea level rise, 331 of the 377 miles of access becomes flooded. **This water level is equivalent to a 100 year storm with 66 inches of sea level rise which is roughly equivalent to the medium - high risk aversion for end of century water levels.**

this water level is lower than the end-of-century estimates for the daily tides in the extreme risk aversion category.
Which also shows most of the public access flooded.
So we have a big task ahead of us to ensure shoreline public access is maintained.

I want to note that all of these scenarios show intermittent flooding that will become more frequent as sea levels rise,
which begs the question of how much flooding is too much? We don't have criteria for this type of flooding for public access amenities such as trails and parks.



AB2800 put together a working group to contemplate just these kinds of questions and published a report about a Path Toward Climate-Safe Infrastructure in which key recommendations include developing guidelines and standards to address these types of criteria. Granted there's a lot more critical infrastructure than trails, but to the mission of BCDC, providing shoreline public access is fundamental. Our work in permitting, compliance and enforcement of shoreline public access would be greatly enhanced by the development of Engineering Design Criteria for Trail Safety and Use with respect to flooding.

Categories of Operational and Life Safety Risks could be identified and criteria could be established to address:

- Trail damage from wave overtopping
- Trail usability with wave overtopping
- Trail usability/operation for/from still water flooding

A Literature Review on Design Criteria for Trails and Roads could help to address

- How deep of still water is acceptable?
- What level of wave action is acceptable?
- What adaptive design elements need to be in place? Curbs, rails, guide poles, signs, gates, etc.

Report Recommendations:

State engineers and architects should work through the relevant professional organizations to advance development of climate-cognizant standards.

Until new standards and codes are in place, State agencies should develop guidelines that go above and beyond minimum standards and codes to meet the goals of the Climate-Safe Path for All.

Policies to Permits: Applying State SLR Guidance

- Thoughts on Risk Aversion analysis method?
- Risk Aversion applied to restoration projects?
- Risk Analysis applied to Maintenance clauses in permits?
- Criteria for adaptation thresholds associated with risk categories?
- H++ projects on the horizon – when to apply this risk category?
- Funding mechanisms as permit conditions?

So here are the questions that staff has been discussing in relation to the updated guidance and our climate change policies.
We welcome your comments and questions.